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McEVOY'S TORPEDO SYSTEM.

THE part that torpedoes will play in all future wars between maritime powers renders them objects of great interest, not only to naval men, but also to the general public. In the late Russo-Turkish war the large Ottoman naval force was of but little avail, although it had the whole of the Black Sea coast and both banks of the Danube at its mercy, from the fact that its commanders assumed, very often erroneously, that all the Russian harbors were studded with mines, and that the same appliances were laid very far out to sea. Looking further back to the American civil war, we find evidence not only of the moral, but also of the destructive powers of torpedoes, and see how a nation with numerous harbors and rivers was able by a system of submarine warfare to defend its coast for years against a powerful fleet, and an enemy that lacked neither courage nor resources. Prominent among the officers who derived practical experience from their connection with torpedo work in the American war was Captain McEvoy, who has since devoted himself to the improvement of submarine coast and harbor defenses, and has, perhaps, done as much as any other single experimenter to bring them to their present state of perfection. One of Captain McEvoy's inventions, viz., his "single main system," which has been adopted by several foreign governments, was, until the last few days, on exhibition at the Westminster Aquarium, and forms the subject of the annexed illustration.

In this system of harbor and coast defense, the whole of a group of moored torpedoes communicate with the station on shore by a single electric conductor. Along this they continually telegraph evidence of their being afloat and in working order, and upon any one being struck by a ship it gives immediate notice of the fact to an observer on shore, who can, if he think fit, instantaneously explode the exact mine without any time spent in preliminary adjustments. Further, each torpedo can be electrically isolated from the rest, and can then be tested so that the continuity of the electrical connections may be determined, or can be exploded without coming in contact with the ship whose destruction is desired.

The single electric cable, which is the medium by which the currents for producing these various effects are conducted, runs from the signal station on shore to a point in the channel or harbor near where the assemblage of torpedoes is situated, and there enters a junction-box. From this box there emerge as many conductors as there are torpedoes to be manipulated, one going to each, and by means of electrically controlled apparatus within the box, any one of these conductors can be separately placed in connection with the main cable, or the whole may be coupled to it at once. At its other end each conductor enters a torpedo, and passes successively through a telephone coil and a platinum fuse, and thence to earth. Over the telephone, instead of the usual mouthpiece there is placed a bell, or a box containing loose shot, which, under the influence of the rolling motion of the waves, continually make a noise that can be heard in a telephone at the central station. The fuse is a piece of platinum wire, through which a current of moderate intensity can be sent without any danger of heating it, but which can be rendered red hot by a more powerful current when desired. The arrangement for effecting explosion by concussion consists of a weight held down to a seat by a spring, but not otherwise secured. When the case is violently struck this weight is displaced, and by its motion brings two contact pieces together, diverting the current from the telephone coil and directing it through an electro-magnet, which maintains the parts in the new position until the exploding current is transmitted, or the current is reversed, when the contact is broken by a spring.

After this general account of the capabilities and mode of action of Captain McEvoy's single main system, we will describe the extremely ingenious electrical and mechanical apparatus by which the various operations are effected. Fig. 1 represents the keyboard at the signal station, Fig. 2 the junction-box, and Fig. 3 the circuit closer and fuse, all these views being one-fourth full size. Fig. 4 is a diagrammatic view of so much of the system as is contained in Figs. 1 and 2, B being the single conductor joining the keyboard to the junction-box, C, and D D the separate conductors from the junction-box to the individual torpedoes. Each of the wires, D, is coupled to one or other of a series of metallic contact-pieces, E, arranged in a circle round the axis of a metallic pointer, F, which can be turned by a step-by-step motion, and thus brought successively into electrical contact with the several contact-pieces, E. The current from the main conductor, B, is first led round the coils of an electro-magnet, G, and then to the axis of the pointer, F, from whence it passes to one of the contact-pieces, E. In front of the electro-magnet is an armature, H, which is attracted when a current of sufficient strength circulates round the electro-magnet, and is withdrawn when the current ceases. From this armature motion is transmitted to a pawl, which works into the teeth of a ratchet wheel on the axis of the pointer, F, so that by sending a succession of currents of sufficient strength through the cable the pointer,

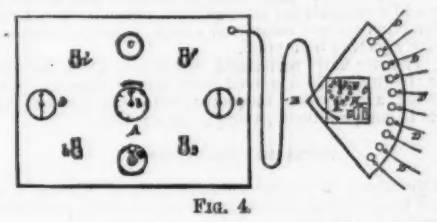

FIG. 4.

F, is turned by a step-by-step motion, and is successively brought into electrical contact with the several contact-pieces, E.

At the keyboard, Figs. 1 and 4, *a* is a handle of a commutator, which in its rotation first connects a battery to the cable for a sufficient length of time to move the index in the junction-box from one contact-piece to the next, and then breaks the circuit. The motion of the index in the junction-box is exactly reproduced upon the dial, *b*, so that the operator knows which of the torpedoes is connected with his instrument.

When the pointer of the dial, *b*, is brought to zero, the pointer, F, in the junction-box is in electrical communication with a contact-point, which is coupled to all of the branch wires, D, and usually the apparatus is left in this condition. The current from the testing battery at the firing point then passes to earth through the resistances in all the torpedoes. If now any one of them be struck by a passing vessel, and its resistance coils be cut out of circuit, in the way to be presently described, the sudden diminution of resistance will be evidenced at the firing point by the increased deflection of the galvanometer, *e*. The movement of the needle effects an electrical connection by which a small battery is caused to sound a bell at *c*. The operator can then, if he please, at once fire the torpedo that has been struck by moving a handle at *f*, and coupling up to the cable a battery of greater strength. The current will divide itself among the fuses according to the electrical resistances in the various circuits, and as that which proceeds directly to earth has much less resistance than the others, that alone will transmit sufficient current to effect ignition. In cases where there is no danger of injuring friendly vessels, the cooperation of an operator at the keyboard may be dispensed with, and the firing battery be permanently connected to the cable by the plug on the right hand side of the bell (Fig. 1).

The explosion of the torpedo leaves one conductor, D, directly connected to earth, and thus prevents the same system of simultaneous testing being applied to the remainder. To avoid this, the wire, D, is then cut off from the contact, E, by the passage of a strong current, which either fuses a connection between the two, or effects the uncoupling by means of an electro-magnet. The operator can tell which of the torpedoes it is that has been fired, by passing the index round the circle, and noticing the deflection of the galvanometer at each step. For taking more accurate measurements of the electrical condition of the cable and fuses a Wheatstone bridge is provided, with a galvanometer, *d* (Figs. 1 and 4), and a small box of resistance coils (shown behind it).

We now come to the very ingenious circuit-closer which is inserted in each torpedo, and telegraphs to the operator at the keyboard the fact of the mine having been struck. This appliance is inclosed within a water-tight metallic case, not shown in Fig. 3, and is screwed into the base of the torpedo. It contains, in addition to the fulminating fuse, a quantity of dry gun-cotton. Damp gun-cotton, as is well known, can be handled with great safety, and cannot be exploded even by an ordinary fuse of the usual dimensions, but if the fulminating tube be surrounded by a small quantity of dry gun-cotton, then ignition will be conveyed to the whole, and damp cotton may be employed with the advantage of greater security and no loss of effect.

From the base of the apparatus there rise two pillars carrying four distinct appliances; first, an electro-magnetic contact maker; second, a tumbling weight inclosed in a case; third, a telephone; and fourthly, at the top, a fuse. The current normally enters through the base, passes up an insulated wire on the side of the case containing the weight, enters the telephone case on one side, and after traversing the coils comes out at the opposite side and goes through the fuse to the body of the apparatus which is the "earth." Under these conditions the sound of the bell or the rolling shot can be heard in a telephone receiver at the keyboard. When, however, the torpedo receives a shock, a weight, which can be seen where the case is broken away, and which is normally held to its seat by a spring, is displaced, drawing up a rod upon which is mounted the armature of the electro-magnet and a contact piece. The effect of this is to put the magnet coils into circuit and to short-circuit the telephone coils. The electro-magnet attracts its armature, maintaining the contact piece in its new position, and the current now flows direct to the fuse and thence to earth, and if the firing battery be in circuit the torpedo explodes. In case the collision should have been caused by a vessel whose destruction is not desired, the operator momentarily reverses the current by the key, *i* (Fig. 4), and the armature falls away, carrying the contact piece with it, and the current returns to its former course.

The case we have been describing, viz., that of floating torpedoes, is evidently much more complicated than that in which the mines lie upon the bottom, or are buried in the sand. In such circumstances a very much simpler circuit-closer would of course suffice, as the mines must be fired by observation.—*Engineering*.

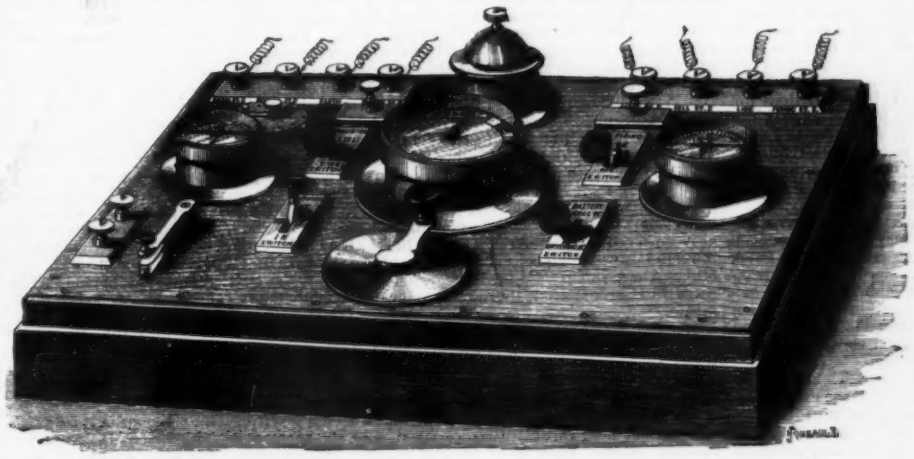

FIG. 3.

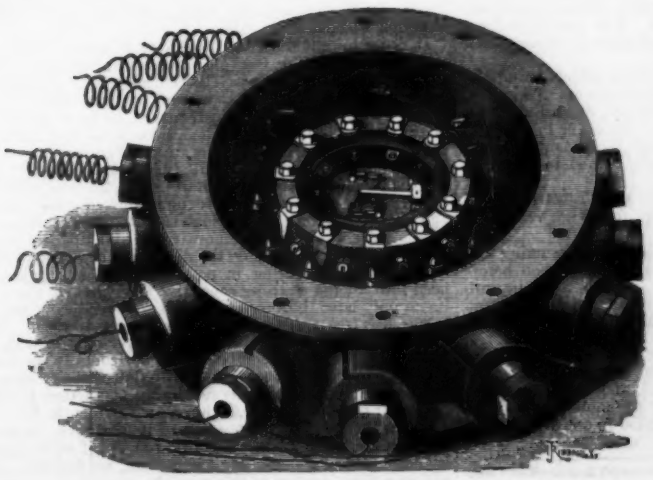

FIG. 2.

McEVOY'S TORPEDO SYSTEM.

THE Edison Co. has applied for permission to light interiors of buildings in Brussels.

THE CAUSE OF EVIDENT MAGNETISM IN IRON, STEEL, AND OTHER MAGNETIC METALS.*

By Professor D. E. HUGHES, F.R.S., Vice-President.

THE extreme sensitiveness of the induction balance to all molecular changes in the structure of metals was remarked in my first paper on this subject to the Royal Society;† and in the case of iron and steel it is most remarkable, as the addition or subtraction of one five-hundred-thousandth part, or the addition of the smallest iron filing to an already large balanced mass of iron, is at once rendered evident and measurable.

Possessing such an invaluable instrument of research, I was desirous of investigating the molecular construction of iron and steel, but at once I met with a difficulty, viz., that magnetism itself completely changed the character of any piece of iron under investigation; consequently, finding no help or explanation of the effects produced from any accepted theories of magnetism, I was forced to investigate, by means of the induction balance, the whole question of magnetism as existing in the interior of a magnet, and to determine the particular structure for each case, such as neutrality and polarity.

In a recent paper to the Royal Society, upon the theory of magnetism,‡ I described the use of and demonstrations obtained by the induction balance. In this paper I propose to confine myself to demonstrations that can be repeated without it, and whose effects can be observed by the aid of ordinary magnetic direction needles.

That magnetism is of a molecular nature has long been accepted, for it is evident that, no matter how much we divide a magnet, we still have its two poles in each separate portion, consequently we can easily imagine this division carried so far that we should at last arrive at the molecule itself possessing its two distinctive poles; consequently all theories of magnetism attempt some explanation of the cause of this molecular polarity and the reason for apparent neutrality in a mass of iron.

Coulomb and Poisson assume that each molecule is a sphere containing two distinct magnetic fluids, which in the state of neutrality are mixed together, but when polarized are separated from each other at opposite sides; and, in order to explain why these fluids are kept apart as in a permanent magnet, they had to assume, again, that each molecule contained a peculiar coercive force, whose functions were to prevent any change or mixing of these fluids when separated.

There is not one experimental evidence to prove the truth of this assumption; and as regards coercive force, we have direct experimental proof opposing this view, as we know that molecular rigidity or hardness, as in tempered steel, and molecular freedom or softness, as in soft iron, fulfill all the conditions of this assumed coercive force.

Ampere's theory, based upon the analogy of electric currents, supposes elementary currents flowing around each molecule, and that in the neutral state these molecules are arranged haphazard in all directions, but that magnetization consists in arranging them symmetrically.

The objections to Ampere's theory are numerous. 1st. We have no knowledge or experimental proof of any elementary electric currents continually flowing without any expenditure of energy. 2d. If we admit the assumption of electric currents around each molecule, the molecule itself would then be electro-magnetic, and the question still remains, What is polarity? Have the supposed electric currents separated the two assumed magnetic fluids contained in the molecule, as in Poisson's theory? Or are the electric currents themselves magnetic, independent of the iron molecule?

In order to produce the supposed heterogeneous arrangement of neutrality, Ampere's currents would have either to change their position upon the molecule, and have no fixed axis of rotation, or else the molecule, with its currents and polarities, would rotate, and thus be acting in accordance with the theory of De la Rive. 3d. This theory does not explain why (as in the case of soft iron) polarity should disappear whenever the exciting cause is removed, as in the case of transient magnetization. It would thus require a coercive force in iron to cause exactly one-half of the molecules to instantly reverse their direction, in order to pass from apparent external polarity to that of neutrality.

The influence of mechanical vibrations and stress upon iron in facilitating or discharging its magnetism, as proved by Matteucci, 1847, in addition to the discovery by Page, 1837, of a molecular movement taking place in iron during its magnetization, producing audible sounds, and the discovery by Dr. Joule, 1842, of the elongation of iron when magnetized, led De la Rive, in his remarkable "Treatise on Electricity," 1853, to give his theoretical views upon magnetism in the following remarkable words:

"The whole of the magnetic molecular phenomena that we have been studying lead us to believe that the magnetization of a body is due to a particular arrangement of its molecules, originally endowed with magnetic virtue, but which in the natural state are so arranged that the magnetism of the body that they constitute is not apparent. Magnetism would therefore consist in disturbing this state of equilibrium, or in giving to the particles an arrangement that makes manifest the property with which they are endowed, and not in developing it in them. The coercitive force should be the resistance of the molecules to change their relative positions."

Wiedermann, in 1861, gives a theory in which he admits the fluids of Poisson, or the elementary currents of Ampere, as the cause of polarity of the molecule, but believes that the molecules are turned in a general direction in the case of polarity, and that in neutrality like Ampere's the magnetic axes of the molecules are turned in all directions.

Maxwell, in his remarkable treatise on "Electricity and Magnetism," 1881, page 73, gives the following *résumé* of Weber's theory:

"Weber's theory differs from Poisson's, in assuming that the molecules of the iron are always magnets, even before the application of the magnetizing force, but that in ordinary iron the magnetic axes of the molecules are turned indifferently in every direction, so that the iron, as a whole, exhibits no magnetic properties." And again, page 429, Maxwell says he agrees with Weber's views, and that neutrality, or unmagnetized iron, has the axes of its molecules placed indifferently in all directions, and that the act of magnetization consists in turning all the molecules so that their axes are either rendered all parallel to one direction, or at least deflected in that direction.

I have quoted these several theories, which admit of the inherent polarity of the molecule, and in that respect they entirely agree with my own; but the induction balance at once shows that they are erroneous in the most important part, for my researches have proved that neutrality is perfectly symmetrical, that there is no case of neutrality where the axes of the molecules are turned indifferently in all directions, and that we cannot obtain perfect neutrality except when the molecules form a complete closed circuit of attraction.

I believe that a true theory of magnetism should admit of complete demonstration, that it should present no anomalies, and that all known effects should at once be explained by it.

From numerous researches I have gradually formed a theory of magnetism entirely based upon experimental results, and these have led me to the following conclusions:

1. That each molecule of a piece of iron, steel, or other magnetic metal is a separate and independent magnet, having its two poles and distribution of magnetic polarity exactly the same as its total evident magnetism when noticed upon a steel bar magnet.

2. That each molecule, or its polarity, can be rotated in either direction upon its axis by torsion, stress, or by physical forces, such as magnetism and electricity.

3. That the inherent polarity or magnetism of each molecule is a constant quantity like gravity; that it can neither be augmented nor destroyed.

4. That when we have external neutrality, or no apparent magnetism, the molecules, or their polarities, arrange themselves so as to satisfy their mutual attraction by the shortest path, and thus form a complete closed circuit of attraction.

5. That when magnetism becomes evident, the molecules or their polarities have all rotated symmetrically in a given direction, producing a north pole if rotated in that direction as regards the piece of steel, or a south pole if rotated in the opposite direction. Also, that in evident magnetism we have still a symmetrical arrangement, but one whose circles of attraction are not completed except through an external armature joining both poles.

6. That we have permanent magnetism when the molecular rigidity, as in tempered steel, retains them in a given direction, and transient magnetism whenever the molecules rotate in comparative freedom, as in soft iron.

EXPERIMENTAL EVIDENCES.

In the above theory the coercive force of Poisson is replaced by molecular rigidity and freedom; and as the effects of mechanical vibrations, torsion, and stress upon the apparent destruction and facilitation of magnetism are well known, I will, before demonstrating the more serious parts of the theory, cite a few experiments to prove that molecular rigidity fulfills all the requirements of an assumed coercive force.

The influence of vibrations, torsion, or stress of any kind upon a magnetized steel or iron rod may be seen by striking with a wooden mallet rods of hard and soft steel, also hard and soft iron previously magnetized to a known degree. The tempered steel, owing to its molecular rigidity, will lose but 5 per cent., the soft steel 60, hard iron 50, and soft Swedish iron 99 per cent. of its magnetism, the amount of loss depending not so much upon whether the metal be steel or iron, as upon its degree of hardness and softness; and as hard steel requires far more power to magnetize it to the same force than iron, it is possible to imagine a steel so hard that its molecules could not rotate, and that consequently no magnetism could be manifested from a given inducing cause, while a perfectly soft iron would give the maximum effect, and instantly return to its previous state. From this we might in error suppose that soft Swedish iron could not retain its magnetism, and that its natural state would be zero or neutrality. The apparent disappearance of magnetism, however, is here due to the extreme freedom of motion of its molecules allowing them at once to follow the comparatively feeble directing force of the earth's magnetism. We can demonstrate this by feebly magnetizing a rod of soft iron held vertically, to that its north pole is at the lower portion. Upon removing the inducing magnet, or electro-magnetic coil, we find that the rod retains a powerful north polarity; but if magnetized in a contrary sense, then we have only *traces* of magnetism left upon the withdrawal of the inducing cause. To succeed in this experiment, as in all others where soft iron is mentioned, we should use the best Swedish charcoal iron, thoroughly annealed at high temperature.

We find, again, that rods of steel or iron will lose far less magnetism when vibrated in the magnetic dip, or vertically when their north poles are at the lowest extremity, than when horizontal or still less than when their poles are contrary to those of the earth's field, and also that they will acquire their maximum magnetism from a given exciting cause when held vertically as described, and the molecules allowed greater freedom of motion to obey the directing influence by vibrations, torsion, stress, or blows upon the iron. Any influence that would tend to give greater freedom of motion, such as heat or mechanical trepidations, gives a far higher magnetic force to the iron than could be obtained without these aids.

In order to render visible the effects of motion upon magnetism, we may take two glass tubes or ordinary phials, of any length or diameter, say 10 centimeters in length by 2 centimeters in diameter. If we now put iron filings in these tubes, leaving about one-third vacant, so as to allow complete freedom in the filings when shaken, we find that each tube, when magnetized, retains an equal amount of residual magnetism, and that this all disappears upon slightly shaking the tube. We are thus imitating the effects of vibration. But if in one of these tubes we pour melted resin (in fact, any slightly viscous liquid, such as petroleum, suffices), we then render these filings more rigid, and then we can no longer produce, by shaking, the disappearance of its residual magnetism. In pouring in petroleum we have apparently been introducing a strong coercitive force, but we know that it can only have the mechanical effect of rendering the iron filings less free to turn, and so comparatively rigid. If we desire to see the effect of torsion, we have only to shake the filings so that when the tube is held horizontally the vacant space is above, and rotate it slightly (but without shaking) about a horizontal axis. Its remaining magnetism instantly disappears upon rotation, although we evidently have not changed the longitudinal position of its particles. A similar effect takes place upon a soft iron rod, for if we magnetize it and observe its remaining magnetism, we find that, upon giving a slight torsion to this wire, its remaining magnetism instantly disappears—a similar effect to that in the rotating tube of iron filings. But if the iron is rendered more rigid by hammering, or steel rendered hard and rigid by tempering, torsions or vibrations have but little effect, as in the case of the filings rendered rigid, as above mentioned. Thus we have no longer need of an assumed mysterious coercive force to account for the retention of magnetism, for once knowing the mechanical qualities of iron and steel, and their degree of molecular rigidity or hardness, we can at once predict their retentive magnetic powers.*

ROTATION OF INHERENT POLARIZED MOLECULES.

Torsion, as well as mechanical vibrations, has, as we have seen, a powerful influence in aiding the molecules to overcome their inertia, and thus aid them to rotate in the direction of the inducing influence; and we may thus polarize strongly a flat, soft iron rod by simply bending or vibrating it when held vertically; and if we measure the magnetic force obtained, we shall notice that the force is strictly relative to the degree of softness of the iron. Thus, with hard steel we should obtain only *traces* of polarization, while with extremely pure, soft Swedish iron we obtain the maximum of force. The bar of iron or steel, being held in the earth's magnetic field, of infinite size compared with the bar, and infinitely homogeneous, cannot deflect or weaken its surrounding field. Its lower portion being north, apparently strengthens it by its reaction, while its upper, south, apparently weakens the field; but, as Maxwell has shown, "the two poles of each molecule are equal and opposite, consequently the sum of each molecule and the whole mass must be zero."

We have a far greater induced polarity in iron or steel when the iron is in thin bars or small wires, and this we should expect, as the external molecules rotate directly under the influence of the earth's magnetism, while those forming the interior of the bar either rotate feebly, or, as in case of very thick bars, actually act as an armature, preventing, by their influence, free rotation of the exterior molecules.

Thus, as the sum of the two and equal polarities in a bar of iron is zero, it is evident that its polarity must be inherent. I have some remarkably pure, soft Swedish iron wire, one millimeter in diameter, and as its inherent polar force seemed great when held vertically in the earth's magnetic field, I measured in the induction balance this force compared with a similar column of the magnetic atmosphere which it displaced. The inherent polarity of this wire, simply rendered evident by the earth's magnetism, was 15,600 times greater than the column it displaced.

We cannot, either by induction, conduction, or concentration, produce a greater force in another body of similar displacement or size, otherwise we could easily create power from a feeble source. Thus the enormously greater magnetic power observed in iron than the same column of air which it displaces must be due to the *inherent* polarity of its molecules.

Among numerous bars of iron upon which I have experimented, one of ordinary hoop-iron, two centimeters wide, forty centimeters long, and one and a half millimeters thick, not softened, possesses sufficient molecular rigidity to be apparently uninfluenced by the earth's magnetism. When this rod is rendered neutral, we have but feeble polarity—mere traces when it is held vertically under the earth's magnetic influence; but if we apply a few successive torsions or vibrations to it when thus held, we have at once several thousand times greater polarity than before. Now, if iron had the power of deflecting or concentrating the earth's magnetism upon itself, it should not require the mechanical aid to molecular rotation given to it by these torsions or vibrations. Thus we are forced to conclude at least the existence of the inherent polarity of the molecules; and, if we admit this, we must also, as a necessary consequence, admit the rotation of these molecules, else we cannot explain why mechanical vibrations allowing freedom of motion should always produce the polarity in accordance with the directing cause. I have already shown that torsions and vibrations *per se* are apparently destructive of magnetism; consequently in this case Poisson's two fluids and Ampere's parallel currents should, according to their theory, be mixed or heterogeneous, while according to the views I am sustaining the polarized molecules should obey, as compass needles, any magnetic directing cause whenever sufficient molecular freedom of motion allows free rotation.

The inherent polarity of iron may again be observed by drawing a flat rod of soft iron over one or both poles of a permanent magnet. This rod will then be powerfully magnetized, its remaining magnetism, when separated from the magnet, being sufficiently powerful to strongly deflect a suspended direction needle. A few slight torsions or vibrations will then completely discharge it. Now, suppose this operation repeated successively many thousand times; if there were no inherent polarity, we should have gradually drawn all the polarity out of the magnet, and discharged it into the atmosphere. Nothing of the kind takes place. The molecules of the iron are simply rotated each time, and the only energy in work expended or lost comes from the arm of the experimenter, and the energy required would be strictly in accordance with the molecular freedom, or softness and hardness of the iron and steel: thus, while soft iron could be easily polarized and discharged by mechanical torsions, hard-tempered steel would require a far greater amount.

Dr. Warren de la Rue, F.R.S., kindly aided me in this part of the research by passing a current from his well-known chloride of silver battery through iron and steel wires. A condenser of 42·8 microfarads capacity, charged by 3·360 cells, was used. We passed this enormous electric charge longitudinally through the wires, and observations were made as to whether any change whatever was produced in their quality or inherent polarity, the result being that these wires gave exactly the same magnetic polarity from a given directing or inducing cause as before, being similar in nature and degree, consequently this enormous electric force had not changed or destroyed the original inherent polarity.

If the molecules possess inherent polarity and rotate upon their axes, similar to a series of compass needles having a slight degree of frictional rigidity, then, upon passing one pole of a magnet above them, they would turn symmetrically in one direction, and drawing the same pole of the magnet in the contrary direction would rotate them, and they would then remain symmetrically in the opposite direction.

A precisely similar effect takes place in a soft iron rod, placed east and west a few inches above a direction needle. Upon drawing the south pole of a powerful natural magnet

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* Paper lately read before the Society of Telegraph Engineers and Electricians.

† "On an Induction Current Balance, and Experimental Researches made therewith."—*Proceedings Royal Society*, March 29, p. 56, 1879.

‡ Proceedings Royal Society, May 10, 1883.

* "On the Molecular Rigidity of Tempered Steel," by Professor D. E. Hughes, F.R.S.—*Proceedings Institution of Mechanical Engineers*, pp. 73-79. Jan., 1883.

at a few centimeters' distance above the wire from east to west, the north polarities of the molecules successively turn in the direction of west, following the attraction of the south pole, as previously seen on the small compass needles. The rod is now magnetized with its north pole west, as indicated by the direction needle below any portion of this rod. Upon passing the same south pole of the natural magnet in a contrary direction, the molecules all rotate, their north poles still turning successively to the south pole of the permanent magnet until its arrival at the end from which the first magnetization commenced. The rod has now entirely changed its polarity, and its north pole is east.

This phenomenon is well known in the ordinary magnetization of rods, where care is taken to draw the magnet always in a similar direction, or the poles would be reversed at each to and fro drawing. To account for this, on the Coulomb-Poisson theory, it would be requisite that, first, all the fluids be separated with their north fluids symmetrically in one direction, but on drawing back the magnet, these fluids would have to mix together, the north fluid passing through its south fluid to be finally opposite to its previous position, its coercive force doing the double work of allowing both fluids to mix and pass through each other, and finally keeping them entirely apart. Ampere's theory would require that from a haphazard arrangement the molecules should become symmetrically arranged upon the first passage of the magnet, then upon its reversed direction one-half of the electric elementary currents should successively revolve in a contrary direction to arrive at neutrality before, finally, the other half followed the direction of the first half, and now all these currents would be revolving in the opposite direction to that upon the first magnetization. We thus see that both these theories, while resting altogether upon assumption, are extremely complicated and improbable.

We might suppose, from the theory which I am advocating, that upon the rotation of the molecules there would be some disturbance or mechanical trepidation; and such is found to be the case, as first observed by Page, and afterward verified by Dr. Joule and De la Rive, in the molecular sounds produced in iron upon its magnetization. Reis' first telephone was founded upon these sounds, and Du Moncel has made numerous researches upon this subject.

In the last of my experiments cited, the sounds are too feeble to be heard, but by the application of the microphone these trepidations at once become audible.

That molecules of iron and other metals rotate with time, whose period becomes shortened by mechanical vibrations, is well known in metallurgy, the ultimate result being generally the passage from a fibrous condition, as in iron wires, to a high degree of crystallization. For many years I employed a circular vibrating spring as the regulator of speed of my printing telegraph instrument, and although this spring was so regulated by means of a frictional brake, or "Frein," as not to surpass its limits of elasticity, these springs were constantly breaking after a few days' use, and as a matter of urgent necessity, I made special researches into the cause of this breaking after a few days' constant vibratory action. I found at the point of rupture a high state of crystallization. Fibrous iron would thus become thoroughly crystallized and break in one day; the number of vibrations for an instrument in constant use during 24 hours being 1,209,600. Thus we could roughly estimate the life of iron in the form of one of these springs at one million vibrations. Copper crystallized in one hour, and all metals and alloys were inferior to steel, except aluminum bronze. The latter springs would stand six week's constant use, or some fifty millions of vibrations. I finally resolved this problem by spreading the amount of vibrating work over a spiral spring containing 3 meters of steel rod wound into the same space as previously held by the straight rod of 30 centimeters; by this means the average life of these springs has become five years. Evidently the molecules of these fibrous springs must have rotated under the vibrations, in order to produce crystals. The same phenomenon is observed in axles of carriages receiving constant trepidations, large crystals being always found at the point of fracture. Again, if we rapidly magnetize and demagnetize an iron rod, we have the production of evident heat, due to the constant motion of its molecules.

Maxwell describes an experiment of Beetz, in which an exceedingly small filament of iron was deposited by electrotype, under the influence of a strong magnetic field, in order to arrive at the inherent polarity of comparatively few molecules, and, as its magnetic force was very great, he regards the experiment as conclusive. My own experiments show that we have far less external magnetic force from a solid bar than from a thin tube or flat bar of the same surface exposed to a limited exciting cause. We know that magnetism does not penetrate to a very great depth, and we also know that, if to a thin steel permanent magnet we place another piece unmagnetized, or, better still, a rod of soft iron, its external polarity is greatly reduced; consequently the external evidence of polarity is not a direct measure of the degree of rotation, nor of the total inherent polarity of its mass. We may have a great superficial *external* rotation superposed upon rotations of an opposite nature, as will be seen later; and thus the internal molecules of a magnet often act more or less as an external armature in closing its circle of attractions.

I have stated my belief that the molecule itself possesses its inherent polarity, which, like gravity, is an endowed quality for which we have no more reason to suspect the cause to be elementary electric currents than that elementary currents should be the cause of gravity, chemical affinity, or cohesion and its polar power of crystallization, most of which are affected by an electric current. We have a certain analogy between electric currents and magnetism, but not so great as the analogy between the magnetic polarity of a molecule and its other endowed qualities.

Magnetism, like chemical affinity, cohesion, and crystallization, has its critical points. Faraday discovered that at red-yellow heat iron instantly lost its apparent polar magnetic power, to be as instantly restored at red heat, the critical point varying in iron, steel, etc., and being the lowest in nickel. This would be difficult to explain upon Ampere's theory, as we should have to admit the instant destruction or cessation of the elementary currents, to be again restored at a few degrees less temperature. It would be equally difficult to explain under my view, if it did not belong to a whole class of phenomena due to the possession by the molecules of various endowed qualities, of which chemistry and all our means of research can only teach us their critical points, without attempting to explain why, for instance, iron has a greater affinity for oxygen than gold. We know that it is so; we know that the molecules of all matter are endowed with certain qualities having certain critical points, and I can see no reason for separating their magnetic inherent polarity from their numerous other qualities.

(*To be continued.*)

LUMINOSITY OF MAGNETS.

By J. T. SPRAGUE.

RECENT experiments by Prof. W. F. Barrett, of Dublin, will direct fresh attention to the statements made many years ago by Baron Reichenbach, which have hitherto met with little or no acceptance from the scientific world. A great number of people have, however, felt that Reichenbach's statements were too definite to be altogether set down as delusion, and that there must be some truth, possibly important, behind them. Reichenbach declared that magnets emitted from their poles a faint luminosity, which became perceptible to eyes which had been kept in absolute darkness for some hours. This in itself makes the experiment difficult, as absolute darkness is not easily obtained, nor are there many observers willing to be confined in it for many hours at a time; but this is certainly necessary, as any one may discover for himself that the eye retains luminous impressions for many hours, and, therefore, would need absolute rest for a considerable period in order to appreciate such a faint luminosity as that under consideration.

But Reichenbach went a great deal further than this, as he declared that a similar luminosity surrounded the human body, and was also generated by the electric current, and by crystals; he attributed it to an unknown force or fluid, which he named od, or odic force, and he contended that this force was essentially linked to vital and other actions. His great difficulty lay, however, in the fact that this light was not only very difficult of perception at all, but that it could only be perceived in any case by a particular class of observers, called by him "sensitives." Now, this class of sensitives coincided with another class, viz., those in a somewhat unhealthy nervous state, and more distinctly with hysterical young women. Therefore, the subject at once passed into the domain of "mesmerism," and was presented to the English public by that very clever but exceedingly extravagant mesmerist, Dr. Ashburner. As a consequence, the scientific world regarded it as a mere matter of charlatanism, or, at most, a piece of hysterical delusion.

Even those who know the truth about mesmerism, and its relation to the occult mysteries of the nervous system, and who were willing to believe that Reichenbach's observations were probably opening a road to useful knowledge, had a great difficulty to encounter. I have myself gone through these experiments, and, moreover, I have found "sensitives" who saw all these phenomena, not in darkness, but in faint light. If this seems difficult, it should be remembered that nowadays we can see and even photograph the faint light of the solar prominences, and even of the invisible corona, which formerly were only visible in a total eclipse: something similar underlies my own statement possibly. But my difficulty was that I could never satisfy myself that what my observers said they saw was in actual existence. I was satisfied they actually saw what they described; my doubt was whether the sight was *objective*, an action exerted from without upon their optic nerve, or whether it was *subjective*, a vision produced from within, by the influence of my own knowledge of what was to be expected.

Now, Prof. Barrett appears to have got over this difficulty. He employed a powerful electro-magnet under the control of observers in another room, and, after a considerable time in darkness, his two "sensitives" perceived a luminosity, and led him up to the magnetic poles; the current was afterward made and broken at irregular intervals, unknown to the observers, who, in every instance except one, simultaneously observed the appearance and disappearance of the glow. It is important to note that, as with Reichenbach, only the specially qualified observers—the sensitives, were able to see the phenomena, which appear to have been imperceptible to Prof. Barrett himself, and three other gentlemen in the room with him. This matter is explainable, and will be dealt with presently.

The north pole of the magnet was said to be the brighter; in the older observations a difference of tint was noted. In both cases it was found that blowing on the poles caused the light to waver, but the laying a board or cloth on the poles did not affect its development, which, however, was arrested when the armature was placed on the magnet.

Although I have never been able to attain proper scientific proof, I have always thoroughly believed that Reichenbach's statements were honestly true; that the observers perceived real natural phenomena, and that the time would come when they would play an important part in science, and probably reveal some valuable secrets of health and the nature of life. I have always been convinced in my own mind, that these luminous appearances over magnet poles were simply representations of the aurora emanating from the magnetic poles of the earth. One of the early experiments consisted of an iron globe containing an electro-magnet which presented the appearance of a luminous body with an aurora of prismatic colors flowing from each pole toward the equator, at some little distance from the surface. It has always seemed clear to me that the aurora was a magnetic light, and not an electric one. Its rays run N. and S., while the electric earth currents run mainly E. and W. In an aurora, magnetic disturbances are produced, and also strong earth currents; if the aurora were an electric discharge, it should produce induced currents parallel to itself, but it does not. Lines in that direction are but slightly influenced, while strong currents are produced in lines at right angles, as they should be if the auroral rays indicated a fluctuation in the magnetic intensity of the earth, produced either by direct magnetic influences, or consequent upon the circulating currents themselves.

My object in writing this article is to clear away some difficulties and prejudices which are likely to affect future observers, and also the reception of their statements. I return, therefore, to the appearances said to surround the human body. My observers described me (as did Reichenbach's) as surrounded by an aura, having a pink tinge on one side and a blue tinge on the other, with brighter rays proceeding from the head and hands; in fact the image presented was just that of pictures of the Transfiguration. Now, as I said before, I am quite uncertain whether this appearance was a real phenomenon, perceptible only to special persons, or whether it was a mere vision resulting from the faculties possessed by those special persons. *But that we are surrounded by such an aura is a positive fact known to all of us.* It is invisible to the eye, but the thermometer reveals it. *It is an aura of heat;* it is a mass of warm air; it is *radiant energy.* Now here is the key of the ideas I wish to present.

We know that from every source of light we can generate a spectrum consisting of three parts, only one of which, the middle portion, the luminous spectrum, is perceived by our eyes. But, after all, we do not see with our eyes, any more than we photograph with a camera. These are merely mechanical appliances for transmitting radiant energy to the true sensitive agent, which, in the case of sight, is ultimately the brain. Now different kinds of glass or crystals modify profoundly the transmission of radiant energy to the sensitive plate, and enable different parts of the spectrum to affect it; also different kinds of receiving plates would give entirely different records of the same spectrum transmitted to them. It is precisely so with our eyes and our perceptions; some people are unable to perceive some colors, or perceive them as others. There is every probability that different people do not see the same luminous spectrum; that to some it extends further to the right, to others to the left. In fact, to some people, orders of rays are visible which are invisible to others. Now Reichenbach asserts that his odic force is refrangible, and belongs chiefly to the violet end of the spectrum. We must remember that in his time it was fully believed that there were three distinct *forces* present in light, which were sifted out in the spectrum; therefore, it was reasonable for him to suppose that he had discovered a new force, "od," associated with heat, light, and actinism, and playing a very important part in nature in those departments hitherto least understood, because this force had not been recognized. It is equally reasonable for us now to believe that in the magnetic field and in many other actions ultra-violet, *fluorescent* rays are produced, and that these fluorescent rays may, in some cases, be perceived as light by people having abnormal powers or organs of perception.

In fact, I have long ago suggested that the auroral rays are of the fluorescent nature, and that they are not visible directly as light, but that they, when at a particular intensity, or when undergoing changes of intensity, act upon the gases and moisture in the upper regions of the atmosphere, and become visible by fluorescence, thus generating lines in the spectrum not associated with any known substance. There can be no doubt of the interest attached to the subject, and various branches of knowledge have progressed so far as to enable us to examine it now with every prospect of advantage, provided it is examined in a broad manner, and with an eye to the physiological problems involved, as well as the purely physical ones. Prof. Barrett knows something of these various aspects of the subject, and will, no doubt, attend to them in further experiments.—*Eng. Mechanic.*

SIMULATION OF ELECTRIC PHENOMENA BY LIQUID OR GASEOUS CURRENTS.

IN a series of researches bearing on the imitation by hydrodynamic way of the mechanical, physical, chemical, and even physiological effects of electricity, I have obtained numerous and conclusive proofs of analogies between the two classes of phenomena, and shall here cite the principal ones.

1. *Imitation of the Phenomena of Electro-Magnetism.*—A long sprinkling tube having been procured and provided at its extremity with a disk flush with the aperture, or with a thick tipped nozzle, is connected with the city water supply. When a current of water passes into this tube held vertically, the aperture being at two or three millimeters from the pavement (or from the flat bottom of some vessel), there occurs a pretty strong attraction, and this force increases in measure as the distance diminishes. But if it now be desired to raise the pipe, there is felt a resistance which increases with the width of the disk and force of the current. We may understand this phenomena if we remember that at the moment water passes from a channel into a wider space there is a diminution of pressure and a suction against the sides; and it is by virtue of this difference between the atmospheric and the internal pressure that the disk is attracted or rather pressed against the fixed obstacle.

On forcing this resistance and leaving the tube to itself, the latter vibrates spontaneously without there being any necessity of holding it; and if a certain pressure be exerted upon it, the rapidity of its vibrations may be increased sufficiently to cause the apparatus to render a sound.

This experiment is comparable with that of an electro-magnet placed under the influence of an automatically broken electric current, as in electric vibrating bells. When, in fact, this vibrating tube is held in the hand, one would imagine that be were dealing with a true electro-magnet, so rapid and strong are the successive effects of attraction and repulsion, exactly like those of magnetization and demagnetization, the action increasing as the distance diminishes. This experiment is capable of receiving dynamic applications.

If, instead of a nozzle with thickened tip or with a disk, there be used one having a thin tip, there will occur a *repulsion* of the tube instead of an *attraction*. It may be easily seen that with either system there may be had a *double acting* apparatus.

2. *Hydro-Induction.*—If the pipe be held horizontally with its aperture far from any obstacle, a *recoil* movement will be felt at the moment the cock is opened, and a forward thrust when it is suddenly closed. Comparing the liquid current to an inducing voltaic current, and the pipe to the induced wire which surrounds the inducing one, these two phenomena are analogous to those that an electric current alternately opened and closed produces in an induced wire. Everything is similar on the one hand and the other. Thus, when an inducing electric current begins, increases, diminishes, or ceases, we know that it gives rise in the induced wire to a reversed, increasing, decreasing, or direct current. This is absolutely the same with the liquid current, and the fact may be easily verified.

3. *Reciprocal Actions of Currents.*—For liquid currents issuing from pipes without nozzles, parallel currents of the same or opposite directions, angular ones, etc., I have found the same laws as for electrical currents. But with thick tipped nozzles or those with disks, the currents (one at least of which is supposed movable) of contrary and directly opposite direction attract each other strongly as soon as the distance of the apertures facing each other is reduced to 0·01 m., and this attraction increases very rapidly in measure as the distance diminishes. If the currents are removed farther apart vibrations occur, and if the nozzles are arranged angularly or eccentrically, an axial force brings them back to parallelism and to a coincidence of their axes. With nozzles having thin tips there is always a repulsion, an axial direction, and vibrations.

4. *Imitation by Liquid or Gaseous Currents of the Lines of Force, or the Magnetic Phantoms obtained with Electric Currents or Magnets.*—In order to imitate the lines of force of an electric current in a plane perpendicular to its direction, it is only necessary to gently blow a continuous current of water through a tapering glass tube perpendicular to a plate of glass covered with a thin layer of red lead mixed with water, the point of the tube being fixed at a few millimeters from the glass. By this means we obtain, around the point at which the liquid falls, quite a large number of concentric circles, formed of particles of red lead juxtaposed after the manner of iron filings under the influence of an electric current.

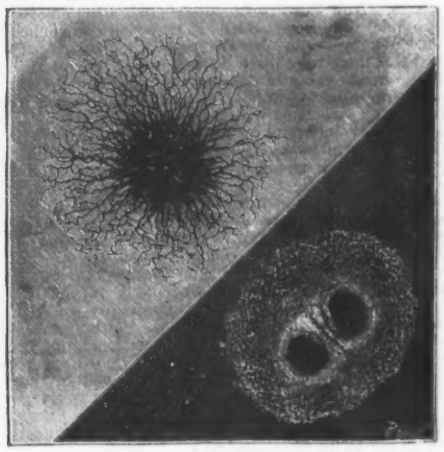


FIG. 1.—Hydraulic imitation of a star-shaped electric spark, and of the lines of force of two parallel currents.

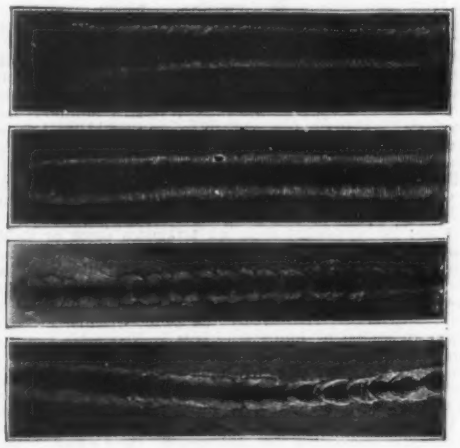


FIG. 2.—Hydraulic imitation of the stratifications of the electric light in rarefied gases.

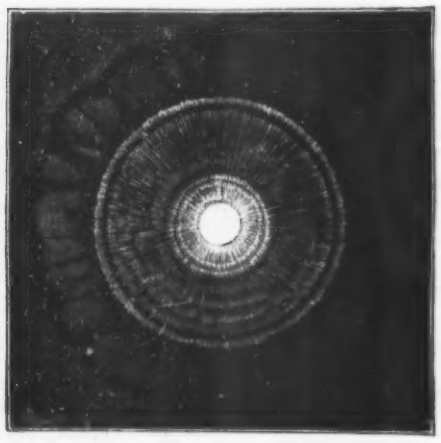


FIG. 3.—Hydraulic imitation of Nobili's rings.

FIG. 4.—Hydraulic imitation of multipolar electro-chemical rings.

SIMULATION OF ELECTRIC PHENOMENA BY LIQUID OR GASEOUS CURRENTS.

In order to imitate the phantom of two parallel currents of the same direction, two tubes analogous to the preceding are employed, and there are thus obtained two systems of curves, which straighten themselves on meeting and repel each other (Fig. 1). In order to imitate the lines of force of an electric current in a plane parallel to its direction, we blow a current of air against the deposit of red lead through a tapering tube held vertically. During this time we move the tube quickly parallel with the plate of glass; and we, so to speak, spread the current horizontally. We thus obtain on the deposit very short and close straight lines that are perpendicular to the direction of the current, and parallel with those given by an electric current on a sheet of paper besprinkled with iron filings.

5. *Imitation of the Forms and Effects of Electric Currents.*—By using the means last cited and substituting suction for blowing, there may be imitated on a plate of glass covered with some heavy, insoluble powder (red lead, vermilion, sulphate of barytes, etc.), mixed with water, the numerous effects of static and dynamic electricity, such as aigrets, sparks, etc. (rectilinear, sinuous, ramified, and starry). (Fig. 2.)

The imitation of Leichtenberg's figures presents the peculiarity that the effect of suction (by means of a pipette in contact with the plate) corresponds to that of positive electricity, and blowing to negative—a result which may have its importance. There may also be very exactly imitated by the moving of the tube the effects of volatilizing a metallic wire by means of the electric discharge.

Among the varied forms exhibited by the stratification of the electric light in rarefied gases, there is one which may be imitated by means of interrupted currents of air, by blowing with a single or double tube against a deposit of red lead and moving the tubes in a regular manner.

6. *Hydraulic Imitation of Nobili's Electro Chemical Rings.*—Of all the imitations of the effects of electricity, this is the most remarkable. The experiment is performed in this way: A jet of liquid is allowed to fall from a graduated glass tube on to a plate of glass, 0·01 m. to 0·10 m., beneath it, covered with a thin and uniform layer of red lead mixed with water. Under these circumstances there are instantly formed on the plate, around the point at which the liquid falls, a series of concentric rings, which vary in number and are unequally spaced, and which are formed by the carriage, mechanically, of the pulverulent deposit under the impelling action of the liquid current. Ordinarily, these rings exhibit very sharp outlines, and diminutions of tint remarkable for their delicacy. There may very frequently be distinguished in them radii that sometimes extend through all the systems of rings and form symmetrical designs that are exceedingly varied and delicate (Fig. 3). These hydrodynamic rings arise from each other, and are propagated in *waves*, as are electro-chemical rings. The only essential difference between these two kinds is that the latter exhibit iridescent colors, and the former do not; and yet this difference is not an absolute one, since Nobili's rings are sometimes dichroic, alternately light and dark. On another hand, the hydraulic rings are not devoid of color, as we may discover on examining them by transmitted light.

By operating hydrodynamically with two, three, four, or more symmetrically arranged tubes, there may be produced on the deposit of red lead those *equipotential figures* that were obtained electro-chemically by Mr. Guebhard, and likened by him to the curves of hydraulic level.

7. *Imitation of a physiological Effect of Electricity.*—This is done by means of an apparatus that I have called the *hydrodiapason*. When this instrument, traversed by a strong current of water, and vibrating rapidly, is touched, a very intense tremor is felt, the sensation being like that which is experienced when the rheophores of an induction apparatus of feeble intensity are touched with the two hands.

After having, in numerous experiments, imitated with liquid or gaseous currents the principal phenomena of static or dynamic electricity, of electro-magnetism and induction, of electro-chemistry and even of physiology, I believe I am justified in concluding, from the similarity of the effects to that of the causes, that electric (and consequently magnetic) phenomena may be likened to hydrodynamic ones; that is to say, electricity in the form of a current is analogous to a liquid current, and, in the form of tension, to a greater or less quantity of liquid spreading itself out all at once like a jet.—*C. Decharme, in La Nature.*

THE INSULITE SEALED BATTERY.

WE herewith illustrate a battery which promises to be very useful. Ordinary batteries have certain disadvantages, which in this are overcome, such as loss of liquid by evaporation, which necessitates frequent supervision; the giving off of noxious fumes; fragility; and so on. An attempt has been made to minimize these serious disadvantages in constructing this battery. It is made with an insulite case (Fig. 1), having a carefully and specially prepared diaphragm, D, placed diagonally across, as shown in Fig. 2. The materials used in charging the cell are somewhat a modification of those in an ordinary Leclanché, viz., carbon surrounded by small lumps of carbon and zinc, with a special excitant, harmless, non corrosive, and non-poisonous. No gas is given off. An insulite lid is fitted upon the cell, and autogenously soldered on. Three holes are left in the lid; through two of these the upper parts of the + and − elements pass, while the third communicates with a stopper and release valve. This valve is provided to allow for the slight variations of pressure in the contained air. The upper parts of the elements are fitted with small rubber cylinders, which by their expansion keep the holes in the lid both gas and liquid tight (see Fig. 2). The terminals are split cylinders, nickel plated, gripping tightly the elements, which project some half inch through the lid, and make good contact. The E.M.F. of the cells is said to be about 1·6 volts, with internal resistance of 1·5 ohms. They are made up singly, in couples, or in sets of three, contained in neat and elegant tin cases. With the release valve screwed tight the cells can be placed in any position, which conduces to their portability. It seems to us that the cells as supplied by the Insulite Company will meet a great want. They are sent out ready for use—no skilled labor is required to install them. The most ignorant of country bellhangers could hardly make a mistake in connecting the bells. On board ship they will be invaluable, as there is no evaporation, no slopping, no corrosion, and no attention required. A zinc rod is said to last about two years, and is then easily replaced. As the applications of electricity extend, and the testing of lightning rods, of electric light wires,

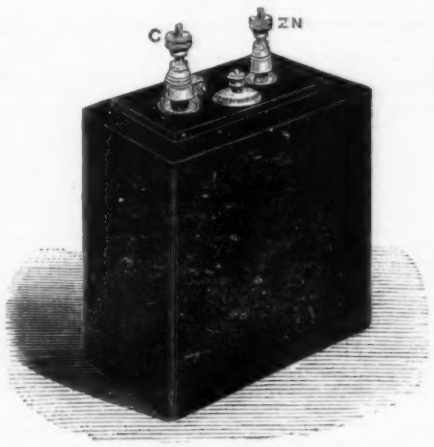


FIG. 1.—INSULITE BATTERY.

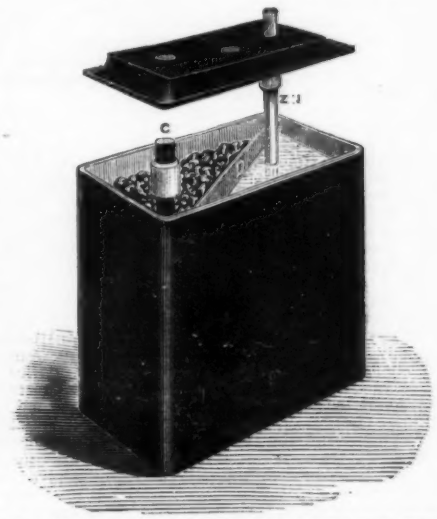


FIG. 2.—INSULITE BATTERY, SHOWING INTERNAL ARRANGEMENTS.

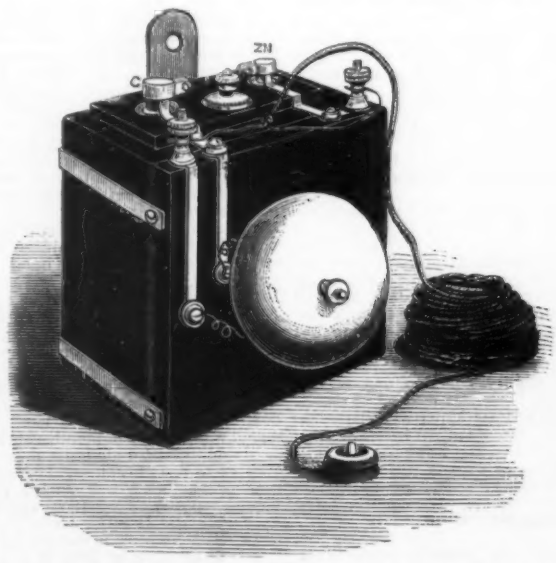


FIG. 3.—INSULITE BATTERY, WITH BELL AND WIRE ATTACHED.

as well as of telephone and telegraph wires, become ordinary work, a portable battery of this kind will be found very useful. Fig. 3 shows an insulite battery, with bell, bell-push, and wire attached for use in a sick room or elsewhere. The electro-magnets and hammer are all contained inside the dome of the bell, which is itself attached to an insulite block, and firmly held to the battery by the strips of metal shown in the figure. The connections are so clearly illustrated as to speak for themselves.—*The Electrician.*

IMPROVED ELECTRIC UNDERGROUND SYSTEM.

THE Continental underground Cable Company, Philadelphia, Pa., is now engaged in the introduction of an improved electric light system and method of laying electric light wires underground, that contains several features of interest and of prospective value.

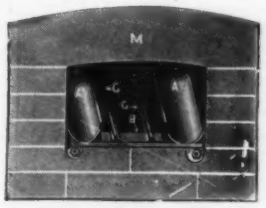


FIG. 1.—Inside measurement, 4½x11 in. Capacity, 400 wires.

The principle involved in this system accommodates itself to the requirements of one or more companies, with the occupation of a very small space, and at a comparative small cost, while it is also possible for several telephone and telegraph companies to occupy one conduit or plant, without interfering with each other.

Within a sectional area of about two feet square, seven thousand (7,000) wires can be laid. The process of laying the wires is extremely simple and rapid—an electric or other motor is run through on the small railway arranged in the

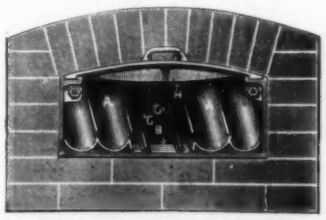


FIG. 2.—Inside measurement, 4½x17 in. Capacity, 800 wires.

conduit, drawing after it one or more cords or small wire ropes which are automatically laid in one or more of the smooth circular pockets or troughs, which latter are preferably made of galvanized sheet iron. A rope thus deposited is attached at one of its ends to a cable of electric wires, the end of which is brought into the manhole, the said cable being then drawn by said rope into position in the pocket or trough and adapted for service; or the motor may be used to draw one rope through, as shown in Fig. 5, and this rope may then be used to draw a carriage through upon the same

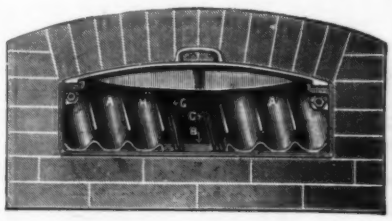


FIG. 3.—Inside measurement, 4½x23 in. Capacity, 1,200 wires.

railroad, the said carriage being adapted to lay wires in one or more pockets simultaneously, either arranged singly or in cables. If a permanent rope be once laid, the carriage alone may be used to deposit auxiliary ropes or electric conductors in the pockets, but if desired the electric motor may be used for this purpose to the exclusion of the carriage.

One of the simplest forms of the system is shown in Fig. 1. A conduit for one or more cables of wires is arranged on either side of the track to accommodate combined 400 wires. The small space and material required will make the cost of construction low.

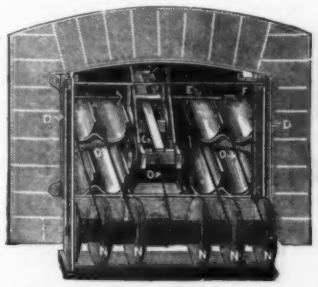


FIG. 4.—Inside measurement, 9x17 in. Capacity, 1,600 wires.

Fig. 2 is on the same general plan, with double the capacity, yet with but a small advance on the cost of construction.

The conduit shown in Fig. 3 will be seen to embody the same principle with capacity of 1,200 wires, and this with a small advance on the cost of Fig. 2.

That shown in Fig. 1 will probably be sufficient for any one company, but where more wires are required the capacity of Fig. 2 should be had, and any single company will probably never require on any street more accommodation for wires than can be had by the conduit shown in Fig. 3; but should a greater capacity be required, the construction shown in Fig. 4 may be used, in which it is seen that the pockets are arranged similar to that shown in Fig. 2, but two deep. In place of arranging pockets as shown in Fig. 4, they may be arranged as shown in Fig. 5; in which the

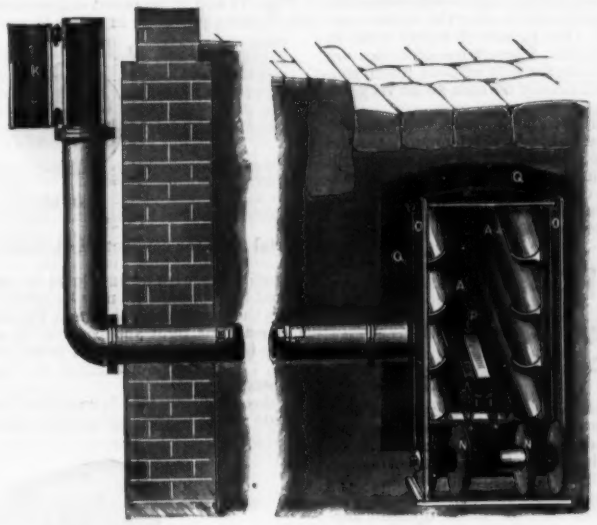


FIG. 5.—Inside measurement, 11x18 in. Capacity, 1,600 wires.

pockets are arranged in single rows one above the other, four deep.

Figs. 6 and 7 show our system for laying wires on a larger scale, and especially adapted to accommodate a number of separate companies, and each of said figures shows the same capacity, but with a slight difference in construction, the arms supporting the pockets in Fig. 6 uniting both uprights, and a track is furnished to each apartment of six pockets; while in Fig. 7 the arms or brackets do not thus unite, but leave a vertical passage way from top to bottom of the conduit wherein the motor or carriage, running upon the rail of the bottom, causes its adjustable arms to travel when in the act of laying the cords, wires, or cables in the various pockets upon either side of said passage way. For an entire city only one motor and one carriage will be required, or if the process of laying the wires is to be carried on by either the carriage or motor alone, then one or the other may be dispensed with; the pockets are made semicircular: three inches wide at the top and an inch and a half deep. The space for the motor is between five and six inches wide, and as it extends from the bottom to the top of the conduit, access to the cables without removing them from their pockets can be had from the top, if at any time it should be desired or become necessary, by removing one or more of the sealed lids. A vertical space of three inches between upper and lower pockets to enable the passage of the motor or carriage arm and also to enable the cable to be tapped and wire taken through an outlet. (See K, Fig. 6.)

Where a number of companies are using the construction shown in Fig. 6, each of said companies can place a suitably arranged lock against admittance to their respective apartments.

Fig. 5 shows an electric motor in the act of drawing a cord or wire cable from a spool supported by an adjustable upright, detachably placed in a manhole for the purpose, this cable when laid being adapted to draw the carriage through, which in turn lays a series of cords or cables in the various pockets, as shown in Fig. 4. If it is required that the carriage make two or more trips successively, then the carriage in being drawn through may also draw through an additional cable (see Fig. 4), by which said carriage may be returned after laying the first lot of cords or electric cable, and be in readiness for a second supply.

Connections from the conduit to houses may be made by a connection run under the sidewalk and into the cellar, as shown in Fig. 5, or by simply tapping the conduit with a leaden pipe, as in making connection to gas or water main, and conveying wires through said pipe into the houses. The conduit before each house is provided with a plugged branch, which may be opened for connection as before explained.

The walls of the conduit may be built of blocks made from asphalt compound, made by an improved process, whereby it becomes impervious to moisture and possesses great strength, and the metal uprights, brackets, and pockets are connected with the earth to carry off induced electric currents to the earth. By this construction the conduit can be built more cheaply than if constructed entirely of iron, and

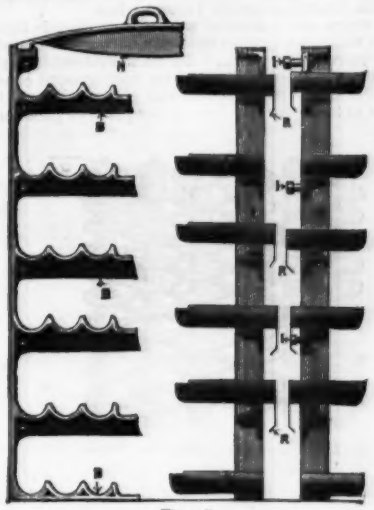


FIG. 8.

in addition thereto is not so apt to become electrically charged.

Fig. 8 shows details of construction. The circular sheet iron pockets are formed by machinery and in sections of four feet long, the ends of which are turned, as shown in Fig. 9, to receive the supporting brackets, which clamp said pockets end to end. The uprights and brackets, B, to receive the pockets, A, are cast in halves, as in Fig. 8, and bolted together in a manner as to clamp firmly the ends of the pockets, thus uniting the adjacent sections, and thereby securing a substantially smooth pocket or trough extending from one manhole to the next, the smooth surface overcom-

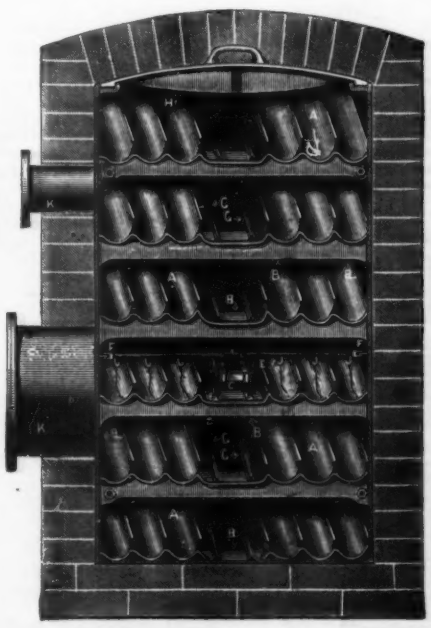


FIG. 6.—Inside measurement, 23x27 in. Capacity, 7,200 wires.

FIG. 7.—Inside measurement, 23x27 in. Capacity, 7,200 wires.

ing any danger of injuring the cables in the act of drawing them through, and at the same time decreasing the labor. The uprights and pockets with the railway are fitted in the machine shop, and several sections when secured together are lowered simultaneously to the foundation made for it in the street.

These are then closed in and the conduit is complete. If desired, a large number of electric cables may be placed in the pockets before they are closed in, and thereby lessen the subsequent work of laying said cables after the entire completion of the said conduit. The process of laying wires in the manner herein set forth, viz., where wires or cables are drawn in or out of one or more pockets without interfering with those in any other, will readily be seen to be very advantageous

When wires are laid parallel and currents of electricity passed over them, every make, break, or change in tension of the electrical current in one or more of said wires will produce induced currents in the other said wires, being inversely proportional to the distance of the wires apart. With telegraphy these induced currents are of no great moment, but with telephony their presence is extremely objectionable,

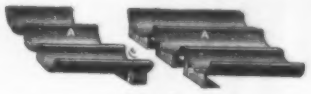


FIG. 9.

for with the small electromotive force necessary in telephonic system, their effects are felt at once and necessitate the application of means to overcome these deleterious effects, which otherwise would so injure the transmission of articulate speech as to render the telephonic system useless. The sheet iron pockets being good conductors and magnetic, tend to carry off the induced currents; the metal uprights supporting the curved pockets being grounded at proper intervals along the line to assist in conveying the induced currents to the earth.

Fig. 10 shows a general view of a portion of an anti-induction cable adapted to underground purposes, and consists of weaving together insulated telephonic wires, A, which form the warp, and bare inclosing wires, B, which form the weft, the said weft being grounded through the agency of the pockets and conduit auxiliary ground wires.

Fig. 11 represents a general view of our electric lighting system, in which we have to deal with currents of electricity of high electromotive force. In such systems in moist weather, or even the dampness of an underground conduit, allows the escape of the current, and so materially reduces its tension as to render the current incapable of producing a

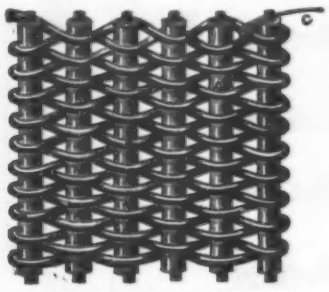


FIG. 10.—Anti-Induction Cable.

light of but small candle power at a short distance from the generating station. Owing to this loss of electrical current, it has heretofore been impracticable to place electric lighting wires underground if the current is to be conveyed long distances.

By this improved system the tension of the current is retained at its maximum, and so far as dampness is concerned the tension is unaffected, thereby enabling us to convey currents underground even longer distances than they can be conveyed underground, under the ordinary variations of the hygrometric state of the atmosphere.

To attain this end we keep the air within the conduit under considerable pressure, and perfectly dry. If there is any appreciable amount of moisture in the atmosphere, the air pump, H, forces the air first through a drier, G, which absorbs all the moisture, and the chemically dried air passes into the conduit, A, and when the pressure becomes over a fixed amount the relief valves, C, allow the excess of air to pass off, thus keeping the pressure in the conduit uniform. Currents of high tension tend to pass off the conductors, but this tendency decreases as the pressure of the surrounding medium (air) increases, and this effect is greatly increased by the thorough drying of the air in damp weather before passage into the conduit. The drying chemicals may be used over and over again, and the system is adapted to any substantially air tight conduit. As the pressure is constant there must be an efflux, and should there be a small leak the passage of air will be from inside outward, thus preventing ingress of moist air.

Figs. 12 and 13 represent end sections of conduits for electric lighting purposes, in which B are the conductors and A

FIG. 12.

a metal pipe, the conductors, B, being supported by suitable insulators within said pipe. The conduit, A, Fig. 11, may be continuous with testing doors in the manholes, B, or if desired the conduit, A, may be open on the ends when it enters the manhole as shown in Fig. 14, in which the door, D, is made air tight and covered by an auxiliary cover, F, on the road, the said door, D, being provided with the relief valve, C. In this construction the manhole is filled with compressed air or gas.

A three inch gas pipe is considered large enough to accommodate all the electric light wires required on any street.

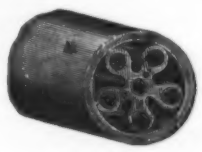


FIG. 13.

This principle may be applied to general conduits, which may also carry the electric light wires, or instead of supplying the whole conduit with compressed air the electric light wires may be inclosed in leaden tubes, and when laid in the conduit air, may be forced under pressure through said pipes.

This is the only practical electric lighting underground system yet presented to the public, and companies will find that such a system would be a great saving to them, as a higher candle power of light can be obtained by its use than with the wires in the air, and this points to a reduction in work required from the dynamo electric machines and steam engines. Besides, it preserves the coating of the wires and

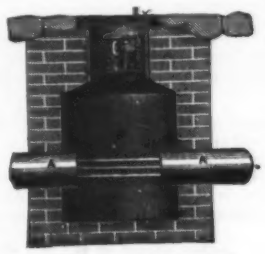


FIG. 14.—Air tight manhole.

keeps them in good condition The pressure pumps need not run except in damp weather, or once in a while in fine weather, so as to keep a pressure in the conduit.

Further information may be had by addressing the general manager of the company, 205½ Walnut Street, Philadelphia.

RESISTANCE OF GLASS.

M. FOUSSEREAU has lately measured the electric resistance of glass by charging a condenser from a known battery through a given thickness of the glass, and observing the time required to raise the potential of the condenser to a given degree. Bohemian glass was found to be from five to twenty times as good a conductor as ordinary glass, while flint glass was from 1,000 to 1,500 times as good an isolator. M. Foussereau found also that annealing the glass increased its resistance in some cases elevenfold.

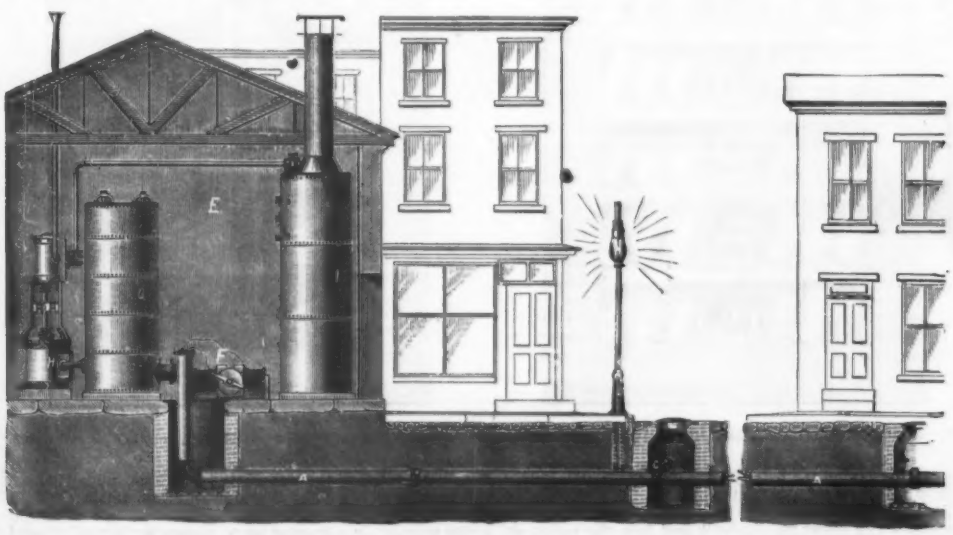
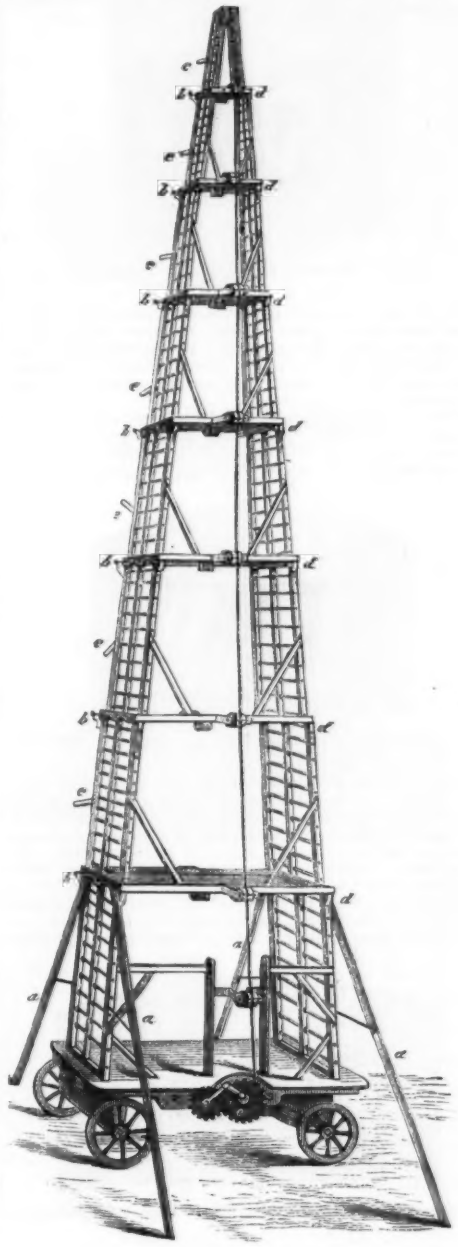
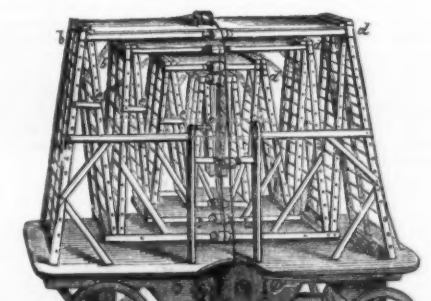


FIG. 11.—UNDERGROUND ELECTRIC LIGHTING SYSTEM.

IMPROVED FOLDING FIRE ESCAPE.

A NOVEL fire escape invented by Mr. F. W. Schwieger, of Leipzig, Germany, is shown erected and folded, in the accompanying cuts. It consists of eight pyramidal sections, one placed on the other, which sections fold within each other when the escape is lowered. The several sections are connected by a chain passing over a windlass drum and over pulleys on the sections in such a manner that, by winding the rope on the drum, the several sections will be raised successively until the ladder attains its maximum height, which is about sixty feet. The vehicle on which the ladder is built is drawn to the burning building, and is suitably braced by means of braces or struts, *a*. Two men turn the crank, *c*, and two other men ascend the side ladders and





IMPROVED FOLDING FIRE ESCAPE.

pass the bolts, *b*, into the lower end of each ladder, for the purpose of bracing them and preventing them from collapsing. The ladder can be erected and folded very easily and rapidly.—*Illustrirte Zeitung.*

ENGLISH PROGRESS IN IRON MAKING.

MR. WILLIAM HAWDON, of Middlesbrough, England, recently read a paper before the Iron and Steel Institute on the substitution of brick lined stoves, of the Cowper or the Whitwell type, for the ordinary pipe stoves in the production of iron, and he stated that he found that by the use of the fire brick stoves, and by increasing the temperature from 900 degrees Fahr. to 1,400 degrees Fahr., a saving of one and a half hundredweight of coke to the ton of iron was

effected, with a large increase in the quantity of the iron and a great improvement in quality. The brick stoves are rapidly taking the place of the iron pipe stoves in the Cleveland district as fast as the furnaces burn out. In the tests made, the best results were secured by a temperature of about 1,400 degrees Fahr., with the following proportions of materials of the charge: Ore, calcined, 47·02, limestone 12·2, coke 22·3, to 458 tons of iron produced. This is a remarkable result, as to the proportion of fuel, when it is considered that the iron produced was of excellent quality, the silicon being less than 2·6 per hundredweight.

FARCOT'S VENTILATING AIR COMPRESSOR.

THE Decazeville coal mines are now employing for the ventilation of their working galleries compressed air under a hydrostatic pressure of 30 millimeters.

Experience had shown that it required a volume of 20 cubic meters per second for the needs of one of the working shafts.

Normally, the wind ways not being obstructed, a pressure of 30 millimeters would be sufficient; but, in order to provide against slides and other obstructions, it became necessary to provide means of furnishing the requisite amount of air under a hydrostatic pressure of 80 millimeters.

This peculiar circumstance necessitated the adoption of some type of ventilator and motor which should be capable of furnishing the requisite amount of air for the two cases, while at the same time it should run with perfect regularity during the mining operations.

The system of compressor which was finally adopted was the one which is constructed by Mr. E. D. Farcot, and which is employed in foundries.

The characteristic feature of this style of ventilator consists in the use of a turbine of peculiar form. This latter is formed of two united conical disks, connected by curved vanes so arranged as to form at the internal circumference an annular chamber which constitutes a reservoir for balancing the pressure and distributing it uniformly throughout all portions of the turbine, thus preventing those differences in pressure in front of and behind each vane that occur in ordinary apparatus of this kind. The vanes are arranged in such a way as to take the air without shock at an angle of about 45°, and are bent at their extremity at an angle of 35° with respect to the radius, so as to force the air to make its exit in the direction of a component more inclined than that which would correspond to the direction of a vane parallel with the radius. The object of this arrangement is to increase the centrifugal force.

The section of the annular delivery between the disks is regulated so as not to be more than half that of the annular delivery measured at the extremity of the vanes. Practice has shown that it is on such a condition that a compression of air may be effected in the annular chamber to a sufficient degree to have its outflow uniform for the entire circumference of the turbine, and that too without the occurrence of any of those eddies that give rise to vibrations, and consequently to a humming sound in those apparatus in which the vanes are prolonged to the extreme circumference.

DETAILS OF CONSTRUCTION

Fig. 1 represents two identical ventilators, 6 meters in diameter, each driven by a peculiar motor devised by Mr. Farcot. Fig. 2 gives an external view of the ventilator, and Figs. 3 and 4 are sections made respectively perpendicular to the shaft of the turbine and parallel with it.

The turbine consists of three cast iron wheels, C, C^1, C^2, each consisting of a hub, four spokes, and a rim cast in a single piece. These three wheels are keyed, at a distance of 0·65 m. apart, to a shaft, A, 180 millimeters in diameter. The intermediate one, C, is prolonged beyond the rim by a circular disk, C, 5·3 m. in diameter, formed of iron plate 4 mm. in thickness. This plate is riveted, in a line with 16 equidistant radii, between two flat irons, D, 75 mm. in width by 12 in thickness, and the extremities of which are fixed by four bolts to the ring that constitutes the rim of the wheel.

The disk, B, is formed of eight iron plate sectors, which are composed of two sheets whose edges are superposed in the direction of two circles, as seen in Fig. 3.

To the rim of each of the wheels, C and C^2, there is fixed a disk in the shape of a truncated cone whose larger base is circular and 5·91 m. in diameter. These disks, C^1 and C^2, which are of iron plate 3 mm. in thickness, are constructed in the same way as the flat disk, C, in the center, excepting that the extremities of the radiating arms, d^1, or d^2, are connected by a flat iron ring 90 mm. in width by 11 in thickness.

The two parallel rings, f and f^1, have a free interval between them of 160 mm. for the exit of the air forced along by the curved vanes, g. These latter, 32 in number, are of iron plate 1·5 mm. in thickness, and their edges are riveted to the sides of the disks, C, C', and C^2.

These disks are cross-braced toward the center of their radius, and to the right of their arms, d, d^1, and d^2, by iron tubes, h, 27 mm. in diameter and 3 mm. in thickness, and the extremities of which are screwed into bronze sockets, h^1, that are affixed to the arms by bolts. These details are shown in part in Figs. 5 and 6.

The stiffness of the whole is further increased by flat irons, i, 55×8 mm., bolted at their bent extremities to the disks. These details are shown in Figs. 7 and 8. The shaft, A, revolves in bronze bearings 400 mm. in length, each set into a cast-iron pillow-block, a. This latter is cast in a piece with two projections through which pass bolts (Fig. 9), thus making its position easy of regulation in order to prevent griping. There is also cast in a piece with it two lubricating cups, the oil from which drips into reservoirs carried at its extremities. The bush, a^1, of the pillow-block is held by keys and a cover in a circular shell, A^1, hollowed out in such a way as to give free access to the air which has been sucked in through the apertures in the ventilator. The circular portion of this shell or box is surrounded by masonry, whose arrangements may be seen in Fig. 2.

The air issuing from the ventilator is forced into a chamber whose lower half is formed in the masonry, while the upper half consists of a shell or jacket, Q, made of 18 mm. thick cast iron, and bolted to the masonry, as shown in Figs. 2 and 4. This shell consists of twenty pieces with flanged edges, which are united to each other by bolts. As may be seen in Fig. 10, these different pieces are not in immediate contact, but are held a slight distance apart by wedges, the vacant space being filled in with cement, so as to prevent leakage through the joints. In the interior of each of the air ports there is fixed a cast-iron ring, Q^1, in front of whose internal edge revolves the external surface of the rim of the wheels, C^1 or C^2, the interval between the two being capable of receiving any desired diminution by means of the regulating bolts, q^1.

The portion of the chamber situated in the masonry connects with a conduit that is shown only by dotted lines in Fig. 2.

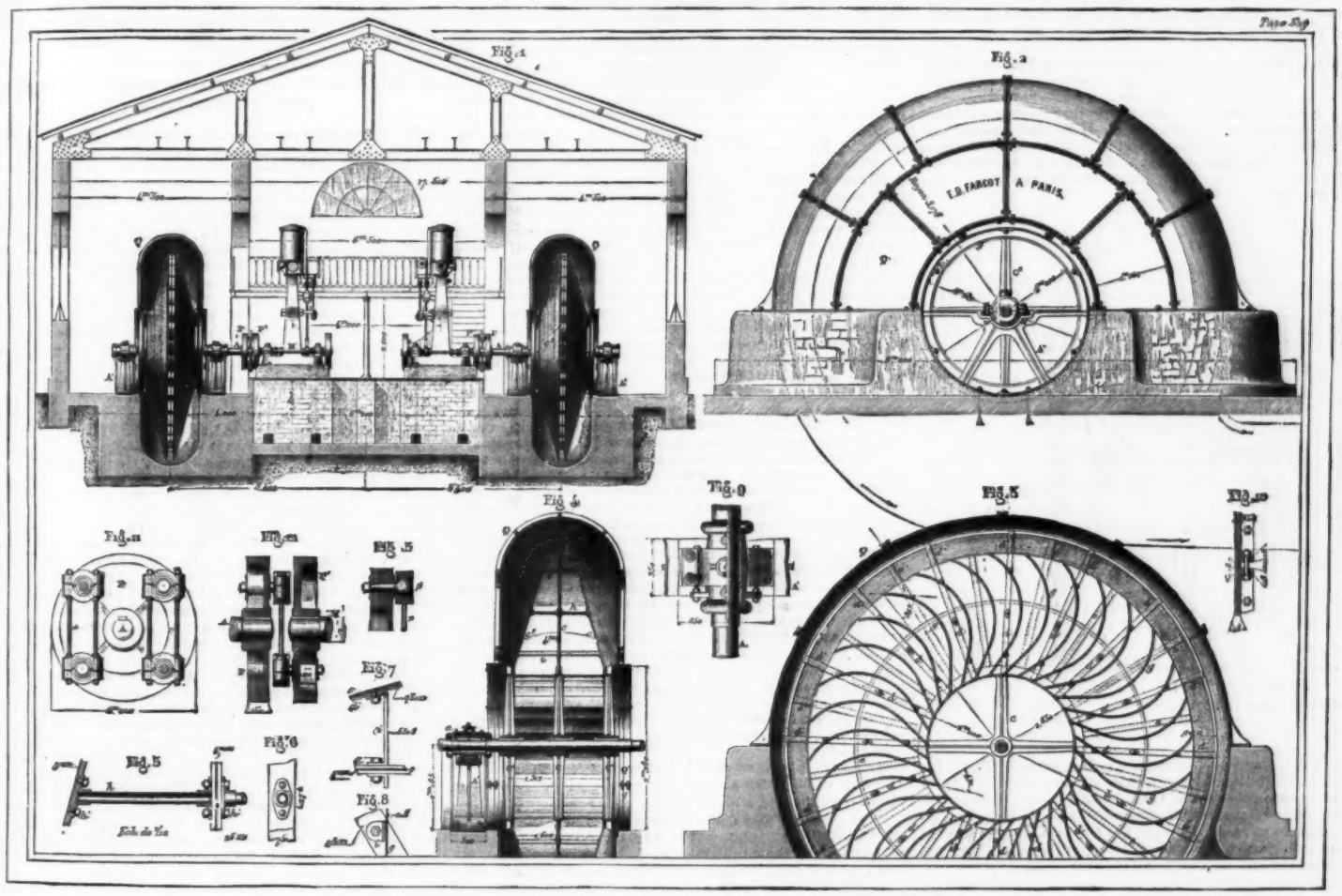
It now remains for us to explain how the shaft, A, of the ventilator is coupled with the shaft, M, of the motor. This coupling is represented in front view in Fig. 11, and in section in Fig. 12. To the extremity of each of the shafts, A, and M, there is keyed a disk, P, and P^1, a portion of which is cast solid so as to form a counterpart with respect to the mass undergoing a rotary motion. To each of these disks there are fixed two spherical-headed pins, p (Fig. 13), those of the disk, P, being connected with those of the disk, P^1, by double cranks, r, 35 mm. in diameter.*

This mode of coupling has the advantage that it permits of a certain amount of play, it not being possible for the two shafts to be exactly in a line with each other without the occurrence of gripings that would interfere with the perfect performance of the machines. The section of the ventilator's air-pipe is 2 square meters, and the velocity with which the air makes its exit is 10 meters per second. The volume of air furnished varies between 20 and 35 cubic meters.—*Publication Industrielle.*

IMPROVEMENT IN THE MANUFACTURE OF ELASTIC RUBBER FABRICS.

THE application of India-rubber to the manufacture of elastic fabrics was made for the first time in France along about the year 1830 by Messrs. Rattier and Guibal at their St. Denis factory. Since then this industry has had some passing success in our country; but, at present, England and Switzerland are furnishing us the greater part of the goods of this kind that are necessary for our use. The prices charged in those countries are somewhat lower than those asked in our own, owing to improvements in the machinery on the one hand, and to the lower cost of manual labor on the other.

The manufacturer of rubber thread receives the material in a natural or a regenerated state, and in threads varying in coarseness, which he is obliged to draw out and reel for the operation of weaving. When this coarse thread has undergone a more or less prolonged maceration in water, to which potash has been added (the object of this being to soften it), the workman takes one of the extremities and



FARCOT'S VENTILATING AIR COMPRESSOR.

attaches it to a reel which he rapidly revolves with one hand by means of a winch. As the thread winds around this apparatus it stretches, since the operator holds it tightly between the fingers of his other hand in such a way as to draw it out to its full extent. The workman, during this operation, wears cloth gloves to prevent the thread from cutting his flesh as it runs between his fingers. When the rubber breaks, the two ends are cut slopingly, their surfaces are applied one to the other, and the thread is rolled with strong pressure between the operator's thumb nails. This makes the adherence perfect.

After the thread has been stretched to the desired degree of fineness, and wound on the reel, it losses all its elasticity after a prolonged tension of from 36 to 48 hours, and may then be wound on bobbins as desired. A counter adapted to the winding frame gives the number of meters wound. The bobbins having been previously tared, the workman, when he supposes that he has wound about 500 grammes upon each one, proceeds to weigh them, and repeats this operation until the weight is exact. At this moment the counter indicates exactly the number of meters wound.

These rubber threads are usually sold by number. No. 1 indicates 100 meters to the kilogramme, and No. 35, which is the one most employed, gives 3,500 meters to the kilogramme.

In order to impart elasticity again to the rubber that has thus been drawn, it has to be submitted to a heat of 60° to 70° C.

The operation of weaving is nearly the same as that employed for all very narrow articles, such as ribbons, galloons etc. With the improvements that we are about to make known, the rubber threads, as warp, are firmly fixed in the

* Through an error of the engraver the cranks are figured too small; their diameter should have been increased one-half.

fabric, whether this be cotton, wool, silk, or other textile material, and it is impossible for them to leave their position when they are traversed by a needle or cut by scissors during the manufacture of objects for which the elastic fabric is employed. The latter, by this very fact, becomes difficult to ravel. The escape movement of the threads of the warp on the wright and wrong side of the fabric being automatic, presents a notable economy over the former escapement by hand. Moreover, changes in temperature have no difference on the work, and the rubber threads undergo no shrinking and do not stick together. This latter trouble has always proved a great obstacle, because of the splitting and breakages of the thread that it caused.

Instead of the threads passing through the heddles of an ordinary harness, they traverse the apertures in one or several plates. These latter are capable of being given a variable, alternating, vertical motion, at will, this being communicated to them by a system of tappets, or some analogous arrangement. Besides these plates, there is also employed at present a new kind of heddle which carries at the center a kind of fork or peculiar needle, through the eye of which passes the rubber thread. The space existing at each side of this needle allows the threads to alternate their position at each motion of the perforated plates. Admitting that we employ rubber threads only, we shall have two called "fixed threads," against one binding thread in the constituent make up of the fabric. The shuttle passes between the first and the second. The latter, as indicated by their name, bind and bury the fixed threads in the thickness of the fabric and form with them a species of tress. It goes without saying that the loom may be constructed with several shuttles as well as with but one only.

Sometimes the binding threads are of some other material than rubber, and in this case they are woven with the warp of the right and wrong side and participate in the automatic escape motion that we shall describe further along. A glance at Fig. 1, which gives a diagram of a loom for weaving elastic fabrics, will suffice to give an idea of the movements of the threads of the warp of the right and wrong side.

In this figure, A_1 A_2 represent the perforated plates; B_1, B_2, and B_3, the rubber threads; C, the new arrrangement of the needle; D, the supports of the warp beams; E E, the beams; F_1 F_2, the lease rods; C C, the warps that concur in forming the face and back of the fabric; H H, the small guide pulleys; and I I, the tension weights. The belts that act as brakes on the beam are figured at J J. K_2 K_3 represent the counterpoises; L_1 L_2, connections between the latter; and M M_2 are stops.

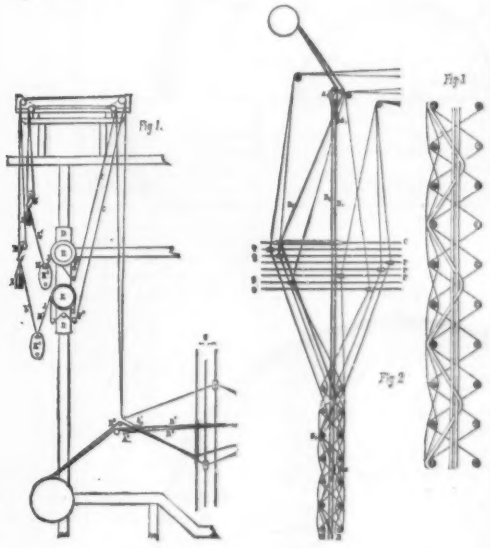


Fig. 2 is a diagram showing the rubber threads, B_1 B_2 B_3, passing through the heddle-needle, C; the binding threads passing through the leaves, O O, of an ordinary harness; the surface threads passing through the leaves, P P P, and those of the wrong side through the leaves, Q Q, and all concurring to form the article *Full Terry*, with the fundamental tweel draught and tie visible on the wrong side.

The diagram in Fig. 3 shows the lease of the rubber warp threads, of the binding threads, and of the face threads for the article called *Imitation Terry*, or Swiss Fabric.

By reference to Figs. 1 and 2, it will be seen that the rubber wires, B_1 B_2, after traversing the perforated plates, A_1 A_2, pass into the upper open part of the heddle-needle, C, and that the thread B_3 runs into the eye of the needle in passing over the plates. These latter, during the weaving, carry along in their motion threads B_1 and B_2, and allow the heddle-needle to slip thread B_3 between the two first. The woof, N, is beaten home in the usual way. After a first pressing of the rubber threads, the plates, A_1 A_2, and the heddle C, take their initial positions during the passage of the number of shoots of the shuttle required by the draught and tie of both sides of the fabric, and then repeat an analogous motion to loop the rubber thread. We have already said that the rubber binding thread might be replaced by any sort of textile thread whatever. In such a case, the latter would operate like threads C C in Fig. 1. The warp beams, as already stated, are mounted upon the piece, D, and the lease rods, F_1 F_2, are attached beneath. The threads, C C, after dividing on these rods, pass to the upper part of the loom and run over the pulleys, H, and finally pass into the harness, S. The friction belts, J J, are fixed to the lease rods and then run over the beams so as to form a brake. The stops, M M, are formed through an assemblage of these stops with the bands, L_1 L_2. The tension weights being suspended, and the loom being in operation, there will be observed a quadruple absorption of the warp threads during the formation of the fabric. This absorption will cause the gradual ascent of the weights, I I, which will, in turn, draw along the counterpoises, K_2 K_3; and these latter, sliding along progressively to the knots, M M_1, and the ascensional motion continuing, will slacken the stops, J J, and allow the beams to furnish the necessary amount of warp.

Fabrics manufactured in the way shown in Fig. 2 are usually called Full-twilled Terry, or, in French, *Terry Croisé Corsé*. For simple shuttle terry the plates A_1 A_2 are placed behind the harness, S, and the heddle, C, in front. These plates, as we have just explained, travel up and down like an ordinary rubber harness, and the movement of the rubber threads may be produced for the body, or right or wrong side of the fabric.—*Le Génié Civil.*

TURKEY RED.

AT a recent session of the Industrial Society of Mulhouse Mr. Camille Kœchlin gave some interesting details concerning Turkey red dyeing on the old system. The modification of the oil upon the fiber, from exposure on grass, takes place only under the influence of light. If a part of the cloth is covered, the oil on such part undergoes no change.

M. Saussure had observed that oil exposed to light may absorb 300 to 400 times its volume of oxygen. However little it may have been once rendered sensitive by the action of the sun, the absorption of oxygen with liberation of heat continues afterward in the dark. In consequence of this phenomenon it is necessary to moisten or to air the cloth after the exposure on grass to prevent ignition. Linseed oil possesses this property in the highest degree. Oil which has been exposed to the sun or to a high temperature decomposes aluminous mordants, and the transformation which it has undergone may be measured by the quantity of mordant which it takes up. The absorption of oxygen, which demands precautions against spontaneous combustions, does not determine the condition of oiling. From a tinctorial point of view it remains a secondary reaction, for the red color may be completed more rapidly than this process of absorption, or the latter may be continued to saturation without the shade manifesting any sensibility to what is going on. During insolation the glycerin is set free from the oil. To assist in this change oils are used in which a part of the oleic acid has been already set at liberty by fermentation. These oils, known as emulsive oils, form with the alkaline carbonates emulsions, in which the oil does not rise up to the surface. The more these emulsions or white baths are alkaline the more readily they are acted on by light or heat, but the more the fatty compound retains its solubility. In practice the proportions are regulated by the weather and the arrangement of the stoves. The dyers were accustomed to add sheep's dung to the white baths, which, by its albuminous nature, strengthened the organic mordant. For the action of light may be substituted that of heat. The procedures based upon this substitution have the advantage of being independent of the weather, and of reducing the operations of applying the oil. These operations may consist of a single strong white bath or of a passage in pure hot oil. The cloth is then stoved at 80°, 100°, or 135° according to the duration of the process; 80° for stoving for several hours, or 130° for hot flues. Cloth steeped in pure oil takes a sulphur-yellow color, followed by a darker and darker yellow, which passes into a brown, and finally into a black. The oil may be carbonized before the fiber. The action is best arrested at a nankin shade. This process is followed by some passages in alkaline water, drying between. The absorption of oxygen is more rapid and dangerous than after exposure to the sun; the cloth must be speedily spread out to prevent accidents. Pieces treated with linseed oil become carbonized if left rolled up or in heaps while moist. An oil which has been heated to 150°, 200°, 250°, 300°, and is then applied to cloth, absorbs oxygen immediately in its fine state of division. The absorption is the more energetic the more strongly the oil has been heated. The final product is a solid resin. Charles Steiner, of Church, Lancashire, devised a process not requiring exposure on grass. This process, which introduced regularity into the numerous operations, as well as the red of MM. Braun and Cordier, was an intermediate step between the ancient process, and that with hydrated oleic acid, due to M. H. Kœchlin. In this process exposure to the sun or to heat is dispensed with, and accidents of spontaneous combustion or heating are not to be dreaded, the oxidation taking place slowly. It was formerly supposed that oiling animalized the fibers, and gave them transparency—suppositions as contrary to chemical as to practical conditions. Though oiled tissues have the property of attracting the majority of soluble coloring matters, like the salts of the oxides capable of acting as mordants, and of rendering colors more permanent. Turkey red is, in fine, merely a madder red, produced upon tissues in which oleic acid has been fixed.

M. Albert Scheurer stated that heating to 120° with hot water is sufficient to clear Turkey reds which have been dyed in presence of a sulpholeate.

M. H. Kœchlin had observed that pieces cleared with one one-hundredth nitro-muriate of tin had spots of mould after the lapse of three or four months. Analogous accidents are still produced under other circumstances, and seem to occur generally when the pieces have been taken through an acid liquid before drying.

M. A. Scheurer is of opinion that clearing Turkey reds consists in a dehydration of the alumina combined with a fatty body. M. Scheurer finds that the temperature at which water produces on a dyed swatch the highest degree of brightness (120° applied for two hours) is exactly that at which the mordant of another swatch prepared under the same conditions, but not dyed, is entirely dehydrated. The dehydrated mordants are with difficulty attacked by acids, and no longer possess the property of attracting coloring matters. Clearing depends as much or perhaps more on the temperature to which the tissue is heated along with water as on the nature of the substances added.

WOODBURY RELIEFS.

THAT the subject of making Woodbury reliefs is of interest to at least a portion of your readers, the leading article in the issue for the 6th April is sufficient evidence, and, as far as I am aware, the process has never yet been published in its entirety. The following method of working (which in my hands is very successful) may be acceptable to those anxious to succeed in this branch of photography. The tissue compound is made of—

Gelatine	2 ounces.
Sugar	½ ounce.
Water	5 ounces.

When the gelatine is dissolved, add thirty grains of bichromate of potash and about half an inch of indigo squeezed out of a Rowney water-color tube. The mixture is then churned with a Kent egg-beater, and filtered through three or four thicknesses of fine muslin.

While the tissue compound as above is being made, three or four 12 × 10 patent plates are cleaned, then polished with French chalk, coated with plain collodion, and allowed to dry. The tissue compound being filtered and the patent plates collodionized and dry, one of the plates is slightly warmed and placed upon a leveling-stand, and sufficient of the tissue compound poured upon it to cover it thoroughly and to the thickness of (say) one-sixteenth of an inch. Allow to remain upon the leveling-stand until the film has set, when it must be removed to the drying chamber. For experimental purposes this drying chamber may be extemporized from an old packing case not too deep, at the bottom of which is placed a zinc tray, two inches deep, half full of dry chloride of calcium. The plate upon which the tissue compound is spread is supported face down over the chloride of calcium by wires stretched across the top of the zinc tray, the wires being so placed as to touch only the smallest possible portion of the film.

When the film is quite dry it is stripped from the grass and placed (collodionized side in contact) upon the negative (duly provided with a safe-edge) in a printing frame and exposed in the sun. Of course the exposure is a matter of great moment, and can only be determined by experiment, the time being measured by means of the actinometer. For a developing support a grained zinc plate is coated with thin India-rubber solution, and allowed to dry.

When the piece of tissue has been exposed sufficiently long it is removed from the frame, placed in cold water, and squeegeed (collodionized side in contact) down upon the India-rubber film upon the grained zinc plate, the tissue and plate being protected with a piece of India-rubber cloth or a piece of single transfer paper, over which the squeegee is applied. After this operation has been performed a short interval is allowed, after which the zinc plate is placed in warm water in a grooved tank, where it must remain for from three to twelve hours to allow of all the soluble tissue compound being dissolved away, the water in the mean time being kept at an equable temperature and free from dirt. When sufficiently developed the plate is rinsed in cold water and placed away to dry, when the relief may be easily detached from the zinc plate.

All the operations are extremely simple, but require great care, the principal cause of failure being *dust and dirt.*—*W. T. Wilkinson, in Br. Jour. of Photo.*

PHOTOGRAPHY APPLIED TO METEOROLOGY AT KEW OBSERVATORY.

DR. BALFOUR STEWART, who is now Professor of Physics at Owen's College, Manchester, had more than any one else to do with originating the photographic system employed at Kew Observatory, of which he was formerly the superintendent. Canson's thin photographic paper is used in the self-recording instruments; the sheets measure 4¼×12½ inches. These sheets are waxed, and Dr. Stewart tried numerous experiments to ascertain the relative value of different waxes for the purpose. He tried carnauba wax, obtained from the Brazilian palm, *Copernicia cerifera*. This is one of the cheapest of vegetable waxes, resinous and brittle, and in good specimens is of a light, yellowish-fawn color. Its market value is from 35s. to 85s. per cwt. He also tried the Chinese white wax, Pe-la, the joint product of an insect, the *Coccus Pe-la*, and a Chinese tree. This wax is not much used in England, and is scarce here. Mr. Leopold Field, of Lambeth, exhibited some specimens lately, and called attention to their properties at a meeting of the Society of Arts. Dr. Stewart also tried myrica wax, obtained chiefly from the berries of the *Myrica cerifera* and, to some extent, from other trees of the same species. He has recorded that their action was found to be purely mechanical. Stearine and most of the oils were too greasy; the fatty acids did not make the paper greasy, but injured the transparency. He also tried paraffine. The result of all Dr. Stewart's experiments was that he found beeswax to be the only wax practically available; but this, in the thin, round tablets four inches in diameter, as sold in the market, is commonly adulterated to the extent of fifty per cent. The yellow bees-wax of the shops is also commonly extensively adulterated. Some American samples have been known to contain no bees-wax at all, except a little rubbed over the exterior of the cake, the bulk being made of resin and solid paraffine melted together. The best way to obtain pure beeswax is to apply for a pure sample to one of the large bleachers.

At the present time the paper used at Kew is purchased ready waxed and pressed; but in former times it was waxed at the Observatory in the following way, as described by Dr. Balfour Stewart: A pencil mark is made on the smoothest side of the sheet of paper, which is the side selected for sensitizing. It is then waxed. The wax is never allowed to reach a higher temperature than 212° Fahr. The apparatus used for the purpose is a tin vessel fifteen inches square and four inches deep, and the tray, one inch deep, which holds the wax, fits into the larger one, which is half filled with water kept at a boiling temperature by means of a gauze gas-burner, giving a heat flame free from smoke and dust. When the wax is perfectly liquid, the sheets of paper taken up singly by one end and lowered on to the fluid; they absorb the wax almost instantly, and are then lifted somewhat quickly by one corner, and the wax allowed to drain off till it congeals on the surface. It then contains more wax than necessary, so two or three unwaxed sheets are then placed on each side of it, and the whole ironed between sheets of white wove blotting paper, and ironed with an ordinary box-iron. Some of the new sheets, if not all, are thus fully waxed, and the imperfectly waxed are made the outer sheets of the new set. Each sheet is finally separately ironed between blotting paper to absorb any glistening patches of wax. It is of the greatest consequence that the heat of the iron should not exceed that of boiling water; so before using the iron it is always dipped into water until the moment the hissing entirely ceases. A properly waxed sheet of paper should present a perfectly uniform appearance.

The paper is now ready for iodizing. Dr. Balfour Stewart's experiments convinced him that the iodizing solution best for a paper to be acted on by solar rays is not the best for a paper to be acted on by lamplight, and it is with the latter we have now to deal. He also tried the effects of adding various kinds of organic matter to the bath, but does not recommend the use of them. They do little or no good, and interfere with the keeping qualities of the prepared paper. The iodizing solution in use at Kew consists of—

Iodide of potassium	582·5 grains.
Bromide of potassium	417·5 "
Distilled water	40 ounces.

The salts are dissolved in the water, and the solution filtered.

A sheet of paper is floated on this bath for ten minutes, care being taken to avoid air bubbles. It is then turned over, and by a slight agitation of the dish made to sink in the solution, after which the same operation is repeated with a second sheet, and so on with others. The sheets

were, in Dr. Stewart's time, allowed to soak in the bath for three hours, with occasional turning about and moving over to let the liquid penetrate between them. At present they are often left in the bath all night. They are then hung up in the air to dry by means of pins bent into the shape of the letter S, by which they are suspended by one corner to a string stretched across the room. In a few minutes a piece of blotting paper about an inch square is stuck to the bottom corner of each sheet to absorb the drop. If the liquid collect in drops all over the surface while the sheets are drying, it is a sign that they have been removed from the iodizing bath too soon. The sheets often assume a dirty pink appearance—perhaps owing to the presence of ozone in the air. This pinkiness is not a bad sign, providing its uniformity indicates that the sheet has been evenly prepared. When dry the sheets are stored in a box for future use; they will keep well for ten months, and how much longer is not known at Kew.

At the present time two or three grains of free iodine are added to the iodizing bath. In Dr. Balfour Stewart's time the sensitizing bath consisted of:

Nitrate of silver	200 grains.
Glacial acetic acid	2 drachms.
Distilled water	20 ounces.

At present it is made up as follows:

Nitrate of silver	900 grains.
Glacial acetic acid	1 drachm.
Distilled water	30 ounces.

The bath is filtered when the solution of the nitrate of silver is complete. When used it is poured into a glass or porcelain dish, alongside which are two similar dishes containing distilled water. The sheet is then floated from five to ten minutes on the silver solution, till it assumes a uniform straw color—or, rather, white, for it looks white by yellow light—when it is lifted and allowed to drain for half a minute, then floated on the water in the second dish; some ten minutes later it is floated on the water in the third dish. In another ten minutes it is rubbed perfectly dry between folds of the pure blotting paper (not Swedish) used in quantitative chemical operations. It is then placed aside in a portfolio until required for use.

After the floating of every fourth sheet the dishes of water are emptied and replenished with fresh distilled water. The silver in the waste liquid is used in the subsequent developing operations. The first of the two nitrate of silver baths described will sensitize about fifty of the sheets already specified, or 3,000 square inches of paper.

The sheets must be kept in perfect darkness, away from gases, fumes, and vapors. The developer originally used was made by first dissolving two ounces of crystallized gallic acid in six ounces of good alcohol, 60° overproof. Hot water is applied to the outside of the flask to aid in effecting the solution of the crystals. The developing solution for 180 square inches of paper was made by mixing ten ounces of the washing liquid already mentioned with four drachms of the exhausted sensitizing bath solution. The mixture was filtered, and half a drachm of the above alcoholic solution of gallic acid added. The exposed sheets of paper are then floated on the developing solution or completely immersed. When the paper has been exposed to moderate light the image begins to appear in five minutes, and is fully developed in a few hours. If the light has been feeble, a day's development or more may be necessary. The sheets should not be lifted for examination more frequently than can be helped, because of the risk of stains. A more intense black than required should be produced, because the color is lowered in the fixing operations.

Under the present system the developer is prepared as follows:

SOLUTION A.

Gallic acid	1½ ounces.
Absolute alcohol	6 ounces.
Glacial acetic acid	½ drachm.

SOLUTION B.

Nitrate of silver	1½ drachms.
Solution A	2¼ drachms.
Glacial acetic acid	¾ drachm.
Distilled water	59¾ drachms.

After being developed, the sheets are well washed in common water, and fixed by being for four hours in a solution of one pound of hyposulphite of soda in one quart of water. When dry the sheets have a granular appearance, which is removed by warning them before a fire or placing them between blotting paper and pressing them with a hot iron.—*W. H. Harrison, in Br. Jour. of Photo.*

[Translated for THE SCIENTIFIC AMERICAN.]

GLYCERINE: ITS MANUFACTURE AND USES IN THE ARTS.

By DR. A. BERGHAUS.

AT the beginning of this century the constituents and constitution of the fats found in the animal and vegetable kingdoms were not yet known, although many of them had been used in a variety of ways for a long time, the manufacture of soaps having been known from the earliest times. Fats were classified according to their origin and their most prominent external characters; their conversion into soaps and plasters was attributed to their direct combination with the alkali, or oxide of lead employed, until Scheele made the discovery, in 1779, that on boiling a mixture of olive oil, oxide of lead, and water, there was formed a non-fermentable substance having a sweet taste which remained dissolved in the water after removing the lead plaster, and that in the saponification of other fats, too, this substance, called by him *oelsüss* (the sweetness of oil), was formed. The true constitution of the fats, the formation of soaps and plasters, as well as the production of this sweet principle, which he named glycerine (γλυκύς, sweet), was first established by Chevreul's celebrated researches on the fats, begun in 1811. In 1814 he discovered that the essential products of the saponification of fats were a greasy substance with acid properties and the neutral glycerine; the first of these united with the alkaline hydrates to form soaps, the second remained free. He proved experimentally that neither the greasy acid substance nor the glycerine was present as such in unsaponified fat, but was first produced during the saponification.

Since that time comprehensive experiments have been made in reference to the properties, decompositions, and combinations of glycerine with other substances. These have not only afforded a valuable support for the chemical constitution of glycerine as recently established, but have also contributed not a little to our knowledge of the chemical constitution of the natural fats.

CHEVREUL'S RESEARCHES.

The view which Chevreul entertained, that fats had a constitution analogous to that of the compound ethers, has been confirmed by these researches; the fats act like ethers of fatty acids. Glycerine stands in a similar relation to glyceryl oxide (glyceryl ether), as common alcohol (ethyl alcohol), does to its ether (ethyl ether, improperly called sulphuric ether). Glycerine, then, is an alcohol, yet not a non-atomic alcohol like common spirits of wine, but a triatomic alcohol. While ethyl ether has only to take up one molecule of water to convert it into ethyl alcohol, glyceryl ether requires three molecules of water to convert it into glyceryl alcohol, or glycerine. This is expressed by the following formulæ, the ethyl compounds being given for comparison:

$$C_4H_9O+HO=C_4H_9O,HO \text{ (or } C_4H_6O_2),$$

ethyl ether + water = ethyl alcohol.

$$C_6H_7O+3HO=C_6H_5O_3HO_3 \text{ (or } C_6H_8O_6),$$

glyceryl ether + water = glycerine.

The above are in the much used but older formulæ of equivalents. In the newer atomic formulæ it would read,

$$C_4H_{10}O+H_2O=2(C_2H_6O),$$

ethyl ether + water = ethyl alcohol,

$$C_6H_{14}O_3+3H_2O=2(C_3H_8O_3),$$

glyceryl ether + water = glycerine,

PROPERTIES.

In its pure state glycerine is a colorless or very faintly yellow odorless sirupy liquid, which has a sweet taste but does not ferment like sugar, has neither acid nor alkaline reaction, feels slippery like oil, and mixes with water and alcohol in all proportions, but not with ether. Glycerine is almost as good a solvent for the alkalies and some deliquescent metallic salts as water; it dissolves no inconsiderable quantity of the oxides of lead and copper. Its specific gravity is 1·26 at 15° C. (59° Fahr.); it is slightly hygroscopic, but at ordinary temperatures is unchangeable in the air; if its solution is evaporated in the air it undergoes a partial decomposition, a brown substance being formed which is precipitated by basic acetate of lead.

EFFECT OF HEAT.

Glycerine can be heated to 150° C. (302° Fahr.), although it begins to evaporate perceptibly at 100° C. (212° Fahr.); then will take fire and burn with a faintly luminous flame; it can likewise be burned with a cotton wick. When heated it gives off a vapor that smells like glue, but, when condensed on a cold body held over it, it is found to be unchanged glycerine. At a higher temperature a portion of the glycerine distills over unaltered, while another portion is destroyed; the residue swells up and gives off a strong and disagreeable odor, which comes from combustible gases, vapors of acetic acid, and a newly formed product called acroleine, which is so unpleasantly perceptible in candle smoke.

EFFECT OF COLD.

At a low temperature (about 18° or 20° C.), glycerine has the property of crystallizing; this will take place rapidly even at + 5° C. (41° Fahr.), as was proved by K. Kraut and A. W. Hofmann (*Berichte der Wiener Ausstellung*, 1873, p. 502), provided a crystal of glycerine is introduced into it. According to V. Von Lang, these crystals belong to the rhombic system. The observation that glycerine would crystallize was made by Crookes, and especially by F. A. Sarg. The investigation of crystallized glycerine was also conducted by Oppenheim and by Van Hamel Roos (*Chem. News*, 1876).

The boiling point of glycerine was found by Mendelejeff (*Ann. Chem. Phys.*, cxiv., 165) and by Oppenheim and Salzmann (*Berl. Berichte*, 1874, 1622) to be at 290° C. (554° F.) under a pressure of 765·5 mm. It can be easily distilled in superheated steam at a temperature of 180° to 200° C. (356° to 392° F). According to Berthelot, it forms a gum which is nearly solid when cooled to —40°C. (—40° F.). If glycerine that contains much water is cooled, the two portions do not freeze without separating, for numerous experiments have shown that only a part of the water changes its state of aggregation, while another and smaller portion seems to stay fluid along with all the glycerine. This reaction can be utilized in the winter months for concentrating to a certain extent a very weak glycerine.

EFFECT ON THE SKIN.

Glycerine produces a feeling of warmth when applied to the skin because it withdraws water from the tissues, thus increasing the influx of blood to the part while the oxygen of the blood produces heat from its increasing the vital activity.

ACTION ON METALS.

Glycerine prevents a precipitation by alkalies of the oxides of the heavy metals, and this property is frequently utilized in medicine. In ordinary therapeutics the peculiar action that certain metals ought to exert is frequently prevented by a circumstance of which the physician is ignorant, or to which little attention is generally paid, namely, that metallic salts introduced into the alimentary system cannot pass into the blood without decomposition. The blood is an alkaline liquid, and precipitates the majority of the metallic salts; coagula are formed, and the metals act only as corrosive topical poisons and are not absorbed into the circulation. Glycerine furnishes a harmless means of keeping metallic oxides in a perfect solution with weak alkalies. If for example an aqueous solution of copper sulphate (blue vitriol) have some glycerine added to it—and it mixes readily with all saline solutions in water—and then if caustic potassa be added, a magnificent blue liquid is formed, but not a trace of any precipitate. If very strong potassa be added to this solution intentionally, and it is then boiled, it will not blacken. The glycerine keeps the oxide of copper dissolved in the alkaline liquid, it prevents dehydration at a boiling heat, it disguises the copper, and this protected or masked state is especially adapted to technical and medical use.

ITS USE IN DYEING.

This property finds a practical use in the operation to be described. It is well known that a process has been patented in England for rendering cotton, linen, and the vegetable fibers in general, which are the hardest to dye, more accessible to the dyes by treatment with concentrated lyes. This process is called mercerizing, from the name of its inventor, Mercer. This process has this advantage—that what are called "dead fibers" of cotton will also take the dye, and that the colors appear much more even and spotless on the vegetable tissues. After they have been subjected to the operation, the fibers have to be pealed or scaled off before putting them in the extract bath and mordanting with salts of aluminum. This mercerization and mordanting must be performed in the same operation, and hence colors are obtained that never are entirely satisfactory because the mordanting must be done in alkaline solutions. This is not easily accomplished without glycerine, although tartaric acid can be substituted for it, but this is expensive, must be employed in large quantities, and does not give so good a shade. If, for example, glycerine is added to the iron mordant, the ordinary ferrous sulphate used by dyers, and then an excess of caustic potash, it will form a solution that is nearly colorless, or light yellow, and from which no protoxide of iron is precipitated by boiling. On introducing into it any cellulose, or vegetable fiber, it will abstract very nearly all the iron from the solution and become more thoroughly mordanted than is possible in any acid solution. The vegetable tissues are mercerized at the same time by the action of the excess of alkali, which partially removes and partially opens up the dead fibers, making them so spongy as to favor the surface action of the dye.

Different tables have been prepared to show the specific gravity of mixtures of water and glycerine, but they are not satisfactory. Until recently that of H. Schweikert was most valued, but as it does not agree with the latest experiments, W. Leutz calculated another table (*Zeitschr. Anal. Chemie*, 1880, 297), which not only gave the specific gravity from 12° to 14° C. (53⅗° to 57° F.), but also the index of refraction accurately determined by Abbe's refractometer. The amount of glycerine was found by an elementary analysis. The optical test can be made very quickly with a single drop of glycerine, and for this reason deserves attention. The small instrument called the per cent. refractometer will answer for observing the bending of the sodium line between 1·3 and 1·43, but for more concentrated mixtures the large refractometer (of C. Zeiss, in Jena) must be employed.

ITS MANUFACTURE.

Glycerine does not occur in a free state in nature, but always in combination with fatty acids, or oleic acid, in the fats and fatty oils. It may be set free in many different ways—by the oils getting rancid, or by decomposing the fats and oils with alkalies, acids, or superheated steam. Glycerine has been made synthetically from compounds of propylen and allyl. Pasteur has shown that glycerine is a constant product of vinous fermentation, and so is succinic acid, but in much smaller quantity. The quantities of each contained in a liter of different wines are as follows:

	Glycerine.	Suc. Acid.
Old Bordeaux	7·4 grm	1·5 grm.
Ordinary "	6·9 "	1·4 "
Old Burgundy	7·3 "	1·5 "
Ordinary "	4·3 "	0·9 "

The proportion of succinic acid to glycerine is nearly as 1 to 5, and quite constant. If the glycerine is present in alcoholic liquors in larger quantities, it is frequently disagreeable. For example, rice whisky has a repulsive, sharp, suffocating odor, which is the more noticeable the higher the temperature was when inverted with sulphuric acid. Hence high temperatures are, as far as possible, avoided, and the sulphuric acid allowed to act slowly for a long time at low temperatures. The odor of spirits obtained from unhulled rice is very penetrating. The cause of this odor, according to J. Bell, is to be attributed to acroleine produced by the action of the sulphuric acid upon the fat of the rice, or by the decomposition of the glycerine at a high temperature. This would explain why liquor having a strong odor of acroleine should be produced at higher temperatures and from unhulled rice, because such rice does contain more fat than that which has been hulled, and the decomposition of fat by sulphuric acid would be more violent at a high temperature than at a low one.

Fats, as we have said, are derivatives of glyceryl; they are in fact compound ethers of the fatty acids and of oleic acid, most of which are solids. The action of caustic potash is shown by this scheme:

$$C_3H_5(O\,C_{18}H_{35}O_2)+3KOH=C_3H_5(OH)_3+(KC_{18}H_{35}O).$$

Tri-stearine. Glycerine. Stearine soap.

The glycerine formed by the process of saponification is rarely recovered, other methods being usually employed for its preparation, especially the saponification with superheated steam, with milk of lime, and with sulphuric acid. In all these methods the fatty acid is the chief product sought, the glycerine being a by-product.

The first method depends on Tilghman's invention, but was practically applied by Wilson. It owes its existence to the decomposition of fats into fatty acid and glycerine, under the influence of steam at a temperature of 180° C. (356° F.), or a pressure of ten atmospheres. Selecting as a example a mixture of stearine and palmitine, we have—

$$C_3H_5\left\{\begin{matrix}OC_{18}H_{35}O\\(OC_{16}H_{31})_2\end{matrix}\right.+3H_2O=$$

$$C_3H_5(OH)_3+C_{18}H_{36}O_2+2C_{16}H_{32}O_2.$$

Stearic acid. Palmitic acid.

The operation is performed in two strong iron boilers, one above the other, the lower one being exposed to the direct heat of the fire. Communication is established between the two boilers by iron pipes connecting the upper and lower portions, causing a continual circulation of the water and fats. When the operation is ended, which takes 8 hours at a temperature of 190° to 200° C. (375° to 400 °F.), the mixture is run out, and when cold the glycerine and water which collect beneath the fatty acids are drawn off. Experience has proved that this yields the best results both qualitatively and quantitatively. The glycerine is but slightly colored and can be easily purified by distillation.

Lime was first employed in place of the customary potash lye by De Milly, in 1834. The decomposition of fats by milk of lime is accomplished in an apparatus called an autoclave; the result is a lime soap and a glycerine solution containing in addition fatty acids and lime. The process goes on according to the formula:

$$2C_3H_5(OC_{32}H_{31}O)_3+3Ca(OH)_2=$$

Palmatine.

$$2C_3H_5(OH)_3+3(Ca[C_{32}H_{31}O_2]_2).$$

PALMATATE OF LIME SOAP.

The liquid has a gravity of about 5 or 6° B. when it leaves the autoclave. The first operation is to remove the lime, which is accomplished by sulphuric acid (more rarely with carbonic or oxalic acid). This also decomposes any soap that may be dissolved in it, and the greater part of the lime is precipitated as sulphate. The crude glycerine that is drawn off requires further purification before it is evaporated. The yield of glycerine (of 30° B.) amounts to 5·6 to 8 per cent. of the fat used.

The third method, decomposition of the fat by sulphuric acid, only gives a satisfactory yield when very carefully conducted. It is better adapted to the manufacture of fatty acids than of glycerine, since the latter is always more or less colored. The excess of sulphuric acid is removed with chalk or barium carbonate. The yield is 4 or 5 per cent. of glycerine of 30° B.

ITS PURIFICATION.

The crude glycerine made by the second or third process, after the removal of the principal part of the lime (or acid) is filtered through bone coal in filters constructed just like those for sugar, as the object in both cases is the removal of the lime. The clarified product is evaporated in vacuum apparatus, for when evaporated over free fire it becomes discolored, especially if not absolutely pure. If the glycerine is still colored, it must be filtered again. Glycerine, treated by the first method, can be easily discolored and immediately evaporated. The product thus prepared is never pure, always slightly colored, frequently contains fatty acids (if lime is removed with oxalic acid, it contains formic acid). For certain purposes a glycerine of special purity is required, and then the crude glycerine must be subjected to a special refining operation.

Two methods of refining are in use, either distillation (rectification) or crystallization. The former was proposed by F. Wilson & Payne in 1855, and patented by them. After the lime is removed or the acid neutralized, the crude glycerine is evaporated at as low a temperature as possible in a vacuum until it has a gravity of 1·15. It is then treated with steam at 110° C. (230° F.), in a special form of boiler, so as to distill off the acids (fatty acids). The residue is then distilled with superheated steam of 180° to 200° C., and the mixture of water and vapor passed into a dephlegmator where the pure glycerine is condensed in the first receiver, a more or less diluted product in the next, and almost pure water in the last one. The dilute glycerine obtained can be added to the next lot of crude glycerine, or returned to the vacuum apparatus. F. A. Sarg's process rests on Sarg's and Crookes' observation, that under certain circumstances glycerine will crystallize. K. Krant found that this crystallization was not spontaneous, as was previously supposed (see above), but that it could be readily produced artificially. In this method the evaporated or distilled product is cooled in tin vessels to 15° C. (41° F.), and pieces of crystallized glycerine thrown in. All the glycerine gradually solidifies in a short time to colorless crystals. The mother liquid can be removed by a centrifugal machine, and the crystals melted again, when the resulting preparation will be perfectly colorless and of excellent quality.

Hermann Krätzer says:

"Since a pure glycerine is preferable for many purposes, impure commercial glycerine may frequently be purified as follows: The glycerine is first diluted with water (it is better to use distilled water), and then agitated for a long time with coarse bone coal and then filtered through a funnel loosely stopped with a plug of asbestos or glass wool. The filtrate is put on a water bath and evaporated to a sirupy consistence.

"Pure glycerine must be odorless and sirupy, white or very light amber colored, and must not redden blue litmus. A sample of pure glycerine evaporated on clear platinum foil should leave no residue."

RECOVERY FROM SPENT LYES.

The residues from whisky stills and the vinasse from the brandy stills of southern France contain glycerine, which might probably be recovered from it profitably. So too the glycerine in the spent lye of the soap makers has not, until very recently, been extracted from it. The process of K. Thomas, W. J. Fuller, and S. A. King, in Bristol, England, consists in evaporating the lye until the larger part of the salt crystallizes out, then drawing off the mother liquor into another pan where a quantity of fatty acid is added which is eight times as great as that of the carbonate and hydrate of potassium in the lye. The mixture is boiled and left to cool. The soap is then taken off, the liquid filtered and refined, distilled, or concentrated, as may be required. H. Flemming, of Kalk, near Cologne, took a patent (Dec. 9, 1880) for recovering the glycerine from the spent lye of soap factories. He advertises regularly that he wants "spent lye from A 1 cured soap, evaporated and prepared by my method." The *Seifensieder Zeitung*, the central organ for soap makers (July 9, 1881), stated that it was able to tell how Herr Flemming prepared this lye:

"In the first place, Flemming required those lyes that had been used for 'fitting' (called 'nigre') should be kept separate from those resulting from the first saponification, and that only the latter, which alone contain glycerine, be furnished to him. If much resin is used in making the soap, the lyes are of no use to him. Flemming then evaporates the lyes to 33° or 34° B., and recommends the use of direct steam and flat, shallow evaporating vessels. The deep boilers used in soap factories are most unsuitable vessels imaginable for evaporation, owing to the great height of the column of liquid to be heated and the difficulty attending the removal of the precipitated salts. When the evaporation is ended and the lyes cooled, a large quantity of salt separates; it is then slightly acidified with concentrated sulphuric acid, which precipitates a large quantity of sulphate of soda, which reduces the gravity of the lye. It is again evaporated to about 33° B., and when cold is put in barrels ready for shipping. Flemming estimates the cost of making such 'prepared lyes' at 10·25 marks per 100 kilos. ($1.16½ per 100 pounds). For this prepared glycerine he offers to pay prices which vary with the distance from the place where it is made, and up to 100 per cent. profit on the cost. We are of the opinion that many large factories are sending their 'prepared lyes' to Flemming, and that he uses them for making glycerine by osmosis, according to a process patented by himself."

CHEMICAL DECOMPOSITIONS.

As already stated, glycerine is a triatomic alcohol, having the formula—

$$C_3H_5(OH)_3 = \begin{matrix} CH_2OH \\ | \\ CH.OH \\ | \\ CH_2OH. \end{matrix}$$

Substances like phosphoric anhydride and potassium bisulphate abstract water from it and produce acroleine:

$$\underset{\text{Glycerine.}}{C_3H_5(OH)_3} - 2H_2O = \underset{\text{Acroleine.}}{C_3H_4O}.$$

Some glyceric ether, $C_6H_{12}O_3$ is also produced.

A new base called *glycoline*, $C_5H_{13}N_3$, has been made by A. Etard (*Comptes Rendus*, 1881) by the action of sal ammoniac at a high temperature.

As glycerine is soluble in water and alcohol in all proportions, and in a pure state abstracts water from other substances, it must be diluted when used for medicinal purposes. It is insoluble in ether, chloroform, benzol, and carbon disulphide, but will dissolve arsenious acid (glycerine arsenic) and also bromine, iodine, alkaline salts, and lime. When iodine dissolves in glycerine, it forms also propylen gas and iodide of propyl. Like all other alcohols, acids convert it into compound ethers and ethereal acids. The compound ethers, excepting trinitrine (nitro-glycerine) and the natural fats and oils, have not found any use. All ethers made from glycerine are called *glycerides*, and are produced by a variety of reactions. When hydrochloric acid gas is passed into glycerine it forms monochlorhydrine, an oily, colorless liquid, boiling at 225° C. This is converted by sodium amalgam into propylenglycol, and that in turn by oxidizing agents into lactic acid (and citric acid has been obtained from dichlorhydrine).

When glycerine is acted upon by a mixture of sulphuric and nitric acids, trinitro-glycerine, $C_3H_5(NO_3)_3$, is produced, an oily, colorless liquid, which is highly explosive. It is the only glyceride that has met with a practical use in great quantities, and we shall speak of it again.

Formic acid is produced when glycerine is heated with oxalic acid, but formic acid unites with glycerine to form monoformine, and when this is heated it gives up nearly all its formic acid. This reaction is of some practical importance, because all glycerine from which the lime has been removed with oxalic acid contains monoformine, and is therefore unfit for medical uses. If glycerine is heated with oxalic acid, about 220° C. (428° F.), it produces allyl alcohol.

The ethers of the fatty acids occur mixed together in the solid and liquid fats, and are seldom used alone, but mostly for making soap and candles.

USE IN MEDICINE AND COSMETICS.

Glycerine mixes with water, alcohol, acetic acid, etc.; it dissolves most substances that are soluble in water, has a greasy feeling like oil, mixes with fatty and fluid oils, does not get rancid, and unites the properties of a fat with those of water; it is well adapted for salves and liniments either alone or as solvent for alkaloids, vegetable acids, etc., and until quite recently found extensive use in medicine, pharmacy, and the cosmetic art.

At present its use in these branches is diminishing, as it has been found that if it is not perfectly pure it may occasion unpleasant irritation if used internally or externally; hence it is now very seldom given internally, while for cosmetic purposes it has a powerful competitor in the indifferent *vaseline*. Nevertheless it is still much used for cosmetics, particularly for soaps.

GLYCERINE SOAPS.

There are many recipes for these soaps, of which we give a few.

TRANSPARENT GLYCERINE SOAPS.

Take of tallow	8	lb.
Cocoanut oil	13	"
Castor oil	3	"
Soda lye (36° B.)	17	"
Glycerine	10	"
Alcohol	17	"

Another is made of:

Cocoanut oil	8	lb.
Tallow	7	"
Castor oil	5	"
Soda lye (38° B.)	11½	"
Alcohol, 90 per cent.	6	"
Glycerine	4	"
Sugar (dissolved in water)	6	"

The whole warmed to 81° C. or 178° Fahr.

A third is made from:

Cocoanut oil	12	lb.
Tallow	10	"
Castor oil (warmed to 82° C.)	6	"
Glycerine	6	"
Caustic soda (36° B.), warm	15	"

Into the above is stirred 2 lb. of alcohol, when saponification will ensue. The kettle must be well closed to prevent evaporation of the spirits, and 5 lb. of sugar solution (1 of refined sugar to 2 of distilled water) added to the soap. The latter is warmed to 75° C. (167° Fahr.) and stirred into the hot soap. This soap is brilliant, and yet cheap to make.

If it is desired to make it without using alcohol, the following proportions are used:

Freshly melted or prepared tallow	10	lb.
Cocoanut oil	12	"
Castor oil	15	"
Caustic soda (35° B.)	22	"
Chemically pure glycerine (28° B.)	3	"
Refined sugar dissolved in 10 lb. water	10	"
Pure crystallized soda	4	"

To make a liquid glycerine soap, 100 parts of oleic acid, freed from stearine as far as possible, are mixed with 314 parts of pure glycerine in a glass flask and heated on a water-bath to about 50° C. (122° Fahr.) and then 56 parts of caustic potash are stirred in. Saponification takes place rapidly; the solution is left to settle for a few days and then filtered. To give the soap a thick, horny consistence, there is mixed with it, after filtering, a quantity of purified potash, equal to one-tenth the weight of the oleic acid used, in just enough hot water to dissolve it. It is finally perfumed to suit the taste.

We find two statements regarding its use as a cosmetic, in which it is said "that glycerine is excellent for preserving the hair. The dandruff, a rapid scaling off of the epidermis, which must hasten the falling out of the hair, cannot be cured quicker in any other way than by rubbing glycerine into the scalp. The result is always certain, and follows with fabulous rapidity as compared with all other and more heroic methods of medical treatment. Since glycerine can be very quickly perfumed, this offers a new use for the stuff. Instead of the pomades made with tincture of cantharides, which are so much used for increasing the growth of the hair, it is advised in all cases to use glycerine that has been digested with a few pieces of Spanish pepper." Furthermore, "Glycerine makes the skin supple, and dissolves or softens all hard masses of fat. If glycerine be dropped on cotton and this pushed back as far as possible in the external ear, considerable warmth will be felt in the ear, and this relieves confusion of hearing and ringing in the ear, and the plug of hard wax soon softens and can be removed. Hence many persons can cure themselves of deafness in a rational manner, when this deafness is due to the sound waves being excluded from the eardrum by hardened wax. Hence glycerine is an excellent remedy, and a German medical adviser has introduced its use; he sold it for a louis d'or per bottle, and cured many deaf persons in a very natural manner by softening the hard plugs of wax in their ears." We will not deny the effect of glycerine in both cases, but it is surpassed by vaseline.

[*To be continued.*]

CHANGES IN THE MILK SECRETION UNDER THE INFLUENCE OF MEDICINES.

By DR. STUMPF.

FROM experiments with goats it was found that small doses of potassium iodide produced an increase of fatty matter and of sugar, with little change in the albuminoids and saline matter. The reaction of the milk, which had been previously amphoteric, became alkaline, and remained so for seven days after the administration of iodine had ceased. Small doses of lead had no appreciable effect upon the quality and quantity of the milk. Morphine had no appreciable effect. Pure ethylic alcohol diluted with water produced no effect upon the quality of the milk; the solids increased, and the specific gravity decreased. The effects of beer were similar. A goat received daily two liters. The sugar and fatty matter in her milk were notably increased.

EXTIRPATION OF FIELD MICE.

By DR. JOSEPH and DR. CRAMPE.

A FATAL cutaneous disease is produced in rodents by the so called "favus fungus" (*Achorion schœnlinii*). The authors propose to apply this fungus to the skin of captured specimens, and then turn them loose to spread the infection.

CEREAL FOODS FROM WHAT WE EAT AND WHAT WE DRINK.

By Dr. A. T. CUZNER, Peekskill, N. Y.*

CEREAL FOODS.

IN the further consideration of the subject of "What we Eat and What we Drink," it will be as well to examine those substances that are raised in the greatest quantities, at the least cost of production, and are more extensively used by civilized people than any other forms of food; I mean the cereals: wheat, corn, oats, rye, barley. Of these, by far the most important is *wheat*. This grain contains all the proximate principles that enter into the composition of the human body, or rather, the proximate principles or *wheat* are so like those of the human body (some being identical) that they are easily appropriated by digestion and assimilation to its nutrition.

EARLY HISTORY.

There are no records in history that take us back beyond the cultivation of the wheat plant. Some believe it was created as it now is, and was from the beginning the every day food of man in the form of bread, from the curse pronounced against Adam, "In the sweat of thy face shalt thou eat bread." In his lamentation for Tyrus, the Prophet Ezekiel says: "Judah and the land of Israel, they were thy merchants; they traded in thy market wheat of Minnitti."

Wheat has been found in the lake-dwellings of the ancient Swiss. From the above we see how ancient the production and commerce in wheat were.

ORIGIN.

The question whether the wheat plant has always been as we now find it, or had its origin in an inferior grass, has not as yet been decided.

A French gardener, M. Fabre, sowed the seeds of a coarse grass, named by botanists ægilops, in the fall of 1837, which ripened in July following.

Its seeds he sowed in the fall of 1840, and continued sowing the seeds every year until 1845, when the plants then raised were regarded by all who examined them as genuine wheat plants.

Its changes from the coarse grass were gradual, at first producing few seeds, but which increased in number as its resemblance to a wheat plant became stronger. It is maintained by Grant Allen that the wheat plant has descended by the processes of evolution and degeneration from the lily; and that, in one of the stages of its evolution, it was a coarse grass, ægilops, mentioned above. See article in *Macmillan's Magazine*, Nov., 1882.

CHEMICAL ANALYSIS.

The following tables, from Prof. E. W. Horsford's report on Vienna bread, may be considered a fair average analysis of good wheat and its ash:

WHOLE WHEAT.

Starch	57·00
Dextrine	4·50
Nitrogenous substances soluble in alcohol, but insoluble in water	0·42
Coagulable albumen	0·26
Albumen soluble in water and not coagulable, two kinds	1·55
Fibrine	9·27
Oil	1·80
Woody fiber	6·10
Extractive matter	1·40
Ash	1·70
Water	16·00
	100·00

ASH.

Potassa	30·00
Soda	3·50
Magnesia	11·00
Lime	3·50
Oxide of iron	1·00
Chloride of sodium	0·50
Sulphuric acid	0·50
Silica	3·50
Phosphoric acid	46·60
	100·00

* A popular treatise on alimentary substances, by A. T. CUZNER, M.D., author of "Food Fishes of the United States," "The Cyclops," and other papers.

MORPHOLOGY.

We will leave for the present the further consideration of the chemistry of a grain of *wheat*, and proceed to investigate its morphology. We will afterward consider separately each of its proximate principles.

Figs. 1 and 2 represent ears of wheat. Grains or kernels of wheat vary from each other slightly in form, according to their variety, but in general they are oblong oval, having

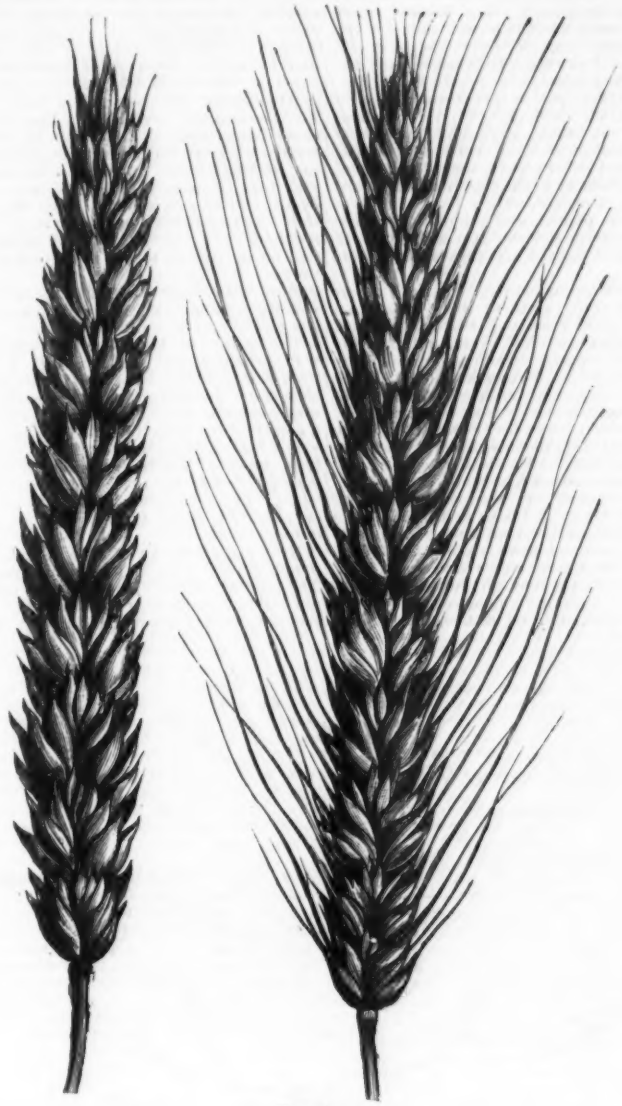


FIG. 1.

a deep groove extending from end to end on one side. At one end of the kernel is the brush of vegetable hairs; at the opposite extremity, under an irregularly curved surface layer of bran, technically called the shield, is the *embryo*.

Fig. 2, A and B, shows both sides of the grain under a power of six diameters. C represents the grain the natural size.

If we make a transverse section of a grain midway between both ends, and expose the cut surface of one-half to the action of iodine, it will assume a purple hue, sharply bounded by the gluten coat. See Fig. 3, B. If we take the other half, and subject its cut surface to the action of a solution of blue vitriol in ammonia (ammonio-sulphate of copper), the starch of the interior will not be changed in

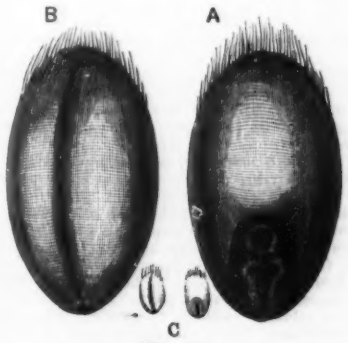


FIG. 2.

color, but the *gluten* will become green from the formation of phosphate of copper. See Fig. 3, A.

The gluten will also readily absorb cochineal in solution, while the starch will remain unchanged.

If a grain of wheat be moistened with water and rubbed between the folds of a rough cloth, the outer covering may be readily detached. If the grain, after having been thus hulled, be treated with a solution of alum, and then with weak acetic acid (vinegar), on cutting it in half as before, digesting with warm water, and subjecting to gentle pressure, the starch and embedded albuminoid bodies may be wholly separated, leaving a layer of cells containing gluten and phosphates attached to or constituting a part of the inner bran coat. There will now remain a cup. If the material removed from the interior of the cup be burned, the ash remaining will be inconsiderable in amount; but if the cup be burned the percentage of ash will be large. We will now examine the structure of a grain of wheat, beginning at the outside and proceeding inward. Fig. 4 represents the different coats peeled and turned back.

First, we have the *epicarp*, or outer coat of longitudinal cells.

Second. The *mesocarp*, or inner coat of longitudinal cells. These constitute the outer true bran.

Third. The *endocarp*, or coat of transverse cells; the inner true bran, or cigar coat.

Fourth. The *epiesperm*, testa, outer seed coat, or color coat.

Fifth. The tegumen, inner seed coat, or gluten comb coat.

Sixth. Interior mass of white, consisting of starch and albuminoid bodies.

Seventh. The embryo.

Fig. 5, after Hand, represents the relative positions of the several investing coats, as seen in a section transverse to the greatest diameter of the grain.

We will now examine the proximate principles that enter into the composition of the different coats and tissues of a grain of wheat; and consider their relative food value in the nourishment of the human body. First, we have the three outer coats constituting the bran. *True bran* is nearly destitute of nutritious properties.

It consists mainly of woody fiber and cellular tissue holding nutritive salts; these salts constituting its whole nutritious value; besides this, it is very irritating to the digestive organs. It absorbs water very readily, and when damp is extremely liable to must or mildew.

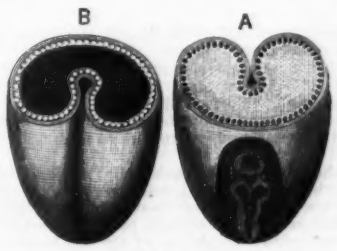


FIG. 3.

If a quantity of true bran be moistened and left in a mass, it speedily ferments and decomposes. The next two coats are mainly composed of cellular tissue, and, like the bran coat, contain nutritive salts; but unlike the *bran*, they are not irritating to the digestive organs. Next, we have the gluten sacs, or perisperm, and as the sacs or their contents (gluten) play such an important part in the economy of nutrition, I shall devote some space to its consideration. When the flour of wheat is made into a dough, and this dough is washed with water and kneaded upon a fine sieve, a milky liquid passes through, from which starch subsides.

GLUTEN.

But on the sieve, when the water ceases to go through milky, there remains a soft, adherent, tenacious, and elastic substance, which can be drawn into long strings, has scarcely any color, taste, or smell, and is scarcely diminished by washing either with hot or cold water. The flour of other kinds of grain also yields it by a similar treatment, though in much smaller quantities.

When the moist gluten is dried in the air at a temperature of boiling water, it diminishes in bulk and hardens into a brittle, semi-transparent yellow substance resembling horn or glue. In this state it is insoluble in water, but dissolves readily in vinegar, in alcohol either hot or cold, and in solutions containing caustic potash or soda. If the crude gluten, as it comes from the sieve, be boiled in alcohol, a solution is obtained which, on cooling, deposits a white flocky substance, bearing much resemblance to *casein*.

When the clear solution is concentrated by evaporation, water separates from it an adhesive mass which consists of a substance to which the name of *glutine* is given, mixed with a little oil. By digesting the mixed mass in ether the

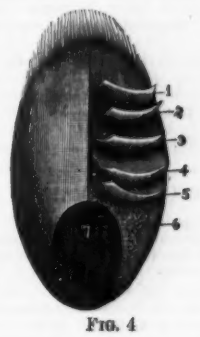


FIG. 4

oil is dissolved out from the glutine, and may be obtained in a pure state by evaporating the ethereal solution. This oil has the general properties of butter. The crude gluten after boiling in alcohol has much resemblance to the fiber of lean beef, and has, therefore, been named *vegetable fibrine*. When the starch has subsided from the milky liquid which passes through the sieve in preparing the gluten of wheat, the water rests transparent and colorless above the white sediment. If this water be heated, it will become more or less troubled, and white films or particles will separate, which may be easily collected, and which possess all the properties of coagulated albumen, or boiled white of egg.

To this substance the name of *vegetable albumen* has been given.

QUALITIES OF GLUTEN.

There is a very important quality possessed by gluten of wheat flour, and not possessed by gluten flours made from the other cereals; namely, *panification*.

This is due to its elasticity and tenacity, by which it is rendered capable of holding gas bubbles in the dough.

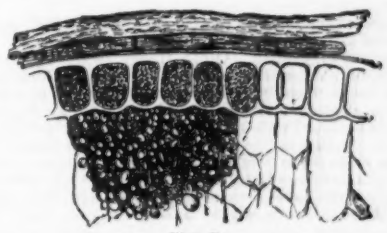


FIG. 5.

"If gluten be washed out of flour and put alone in the oven, it will swell up, become full of pores, and assume a large size.

"The comparative baking qualities of different samples of flour may be judged by the height to which, in similar vessels, the gluten of equal weights of flour is thus observed to rise."

This quality is due *not* to the *crude gluten as a whole*, but to *that substance* obtained as described above from the solution of crude gluten in alcohol, and called *glutine or vegetable fibrine*. Other cereals contain but a small percentage of it, their crude gluten being made up mainly of vegetable albumen and caseine.

There is another property possesed by gluten, viz., its power of absorbing water. Ordinary flour of commerce will take up in bread making one-half its weight of water.

We now come to the consideration of the mass of the interior of the grain of wheat. But a small percentage of this mass is albuminoid, the remainder being made up of starch.

ARE BORACIC ACID AND THE BORATES POISONOUS?

THE *Chemiker Zeitung* of April 1 says that the proprietor of a dairy was brought before a court in Berlin charged with adulterating his milk in having added 0·6 gramme of a boracic acid preservative to the liter (36 grains to a gallon) of milk. Prof. A. Müller, Private Medical Counsellor Wolff, and Dr. Bischoff, chemist, testified at the trial, which resulted in acquittal.

The extensive and increasing use of borates and boracic acid as food preservatives renders it an important if not a vital question whether they are injurious. Boracic acid is not, in any form, a natural constituent of the animal body, nor yet of plants, or of any article of natural food. We therefore think we will do our readers a benefit by translating for them the following article on this subject, from the *Journal de Pharmacie et de Chimie:*

Boracic acid and its different compounds, such as boroglycerides, sodium and calcium glyceroborates, etc., which have recently come into commerce as preservative agents, have acquired such an importance that it would seem hardly possible for us to give too much attention to the question whether boracic acid, either alone or in any combination, can exert any injurious effect upon the system. This is the more important, because Gade, the English hygienist, observed symptons of poisoning after using milk preserved with boracic acid. On the other hand the

experiments made by Ferdin. Vigier in common with Laborde and Rondeau show, as previous experiments had done, that boracic acid, even in quite large doses, is not in the least poisonous, if it is pure, especially if it is free from salts of alumina and lead, also from carbonate of soda, the impurities present in commercial borax.

Dogs fed upon an exclusively animal diet with twelve grammes (186 grains) of borax daily or *ten times* as much as was required by Jourdes's process to preserve his meat, suffered no disturbance of nutrition, but exhibited an extraordinary increase of weight. Vigier attributes this to the action of borax (in place of common salt) in rendering the meat more easy to assimilate, even if the food be exclusively albuminous.

After taking borax the saliva flows more freely and its reaction is more strongly alkaline, so that for seven or eight hours after taking it there is a slight alkaline taste in the mouth. In doses of three and a half grammes (54 grains) it neither causes nausea nor bad feelings, but increases the appetite.

In the saliva boracic acid can only be detected with certainty by means of the spectroscope, but is more easily detected in the urine; yet it takes longer to reach there, so that it can be distinctly detected there twenty-four hours after taking.

Boracic acid remains in the system so long that it is well adapted to combat many infectious diseases.

If this recent investigation of Vigier proves the harmlessness of boracic acid, it applies only to *pure* preparations, and hence care must be taken in using boracic preservative agents to obtain substances that are as pure as possible.

"MUSCLE *vs.* BRAIN."

THIS heading, which is a popular one, aptly illustrates the misconception that prevails in result of ignorance of the laws of physiological development. It is a radical error to suppose that one part of the organism can be or ever is developed "at the expense" of some other. One part may be neglected while attention is exclusively directed to another part, but the fault does not consist in the overcare of the one, but in the neglect of the other. It is important to recognize this, because the phrase "muscle vs. brain" would seem to imply that if we have muscle we cannot have brain. It is needless to remind those who understand the physiology of the higher animal life that no such alternative is presented. Each and every part of the body grows as it feeds. The point which is too commonly forgotten is that it feeds as it works, and in that proportion only. If any part is unexercised, it cannot possibly be nourished in such manner as to produce full growth and good health. In the training of youth it is especially necessary to bear this in mind.

To produce good brain tissue there must be good brain exercise. The work done should not be sufficient to exhaust the organ, or the faculty of recuperation will be itself weakened and exhausted, and then the function of repair will lag behind the function of special activity with the result of deterioration instead of progressive development. The work done should not, as a matter of fact, exceed such limits as regards quantity or quality as shall suffice to stimulate growth without exhausting. An overburdened or overworked brain cannot be healthy, nor can one that is underworked. Fatigue—we mean mental weariness—should not be incurred by the young; that is, during the period of development.

The same rule applies to muscle cultivation. Full exercise without exhausting fatigue is the best, and, indeed, the only stimulant of growth. Other things being equal, the best organism, the healthiest man, will be one in which both brain and muscle have been developed side by side by a process of educationary training in which time and strength have been so utilized as to afford opportunity for growth in every direction, in what we call *mind*—*i. e.*, brain function—as well as in physical strength or muscle function. After the organism has passed through the stage of growth, and its several parts have been finally formulated, there may come a time when muscular activity will so drain the strength as to impoverish the brain, but this state of matters is not reached until long after the educationary period, and in a well trained organism it will never be reached at all.—*Lancet.*

NORTHERN LIMITS OF THE PRINCIPAL FOREST TREES OF CANADA, EAST OF THE ROCKY MOUNTAINS.

A VERY interesting and instructive feature of the recent Report of Progress—1879–80—of the Geological Survey of Canada is the section in Dr. Bell's Report on Hudson's Bay devoted to a description of the northern limits of forest trees, accompanied with a very explicit and serviceable map, details of which are copied in the chart accompanying this summary. The map of the report outlines the winding and tortuous boundaries which climate and conditions of exposure or natural protection have imposed upon the northward extension of thirty species of forest trees. These lines indicate the general extent of the entire growth of each species, the occasional appearance of outliers or even small groups of trees beyond the main body being disregarded. As Dr. Bell remarks: "The usefulness of such a map is not limited to the subject in hand, but acquires collateral importance from the deductions it permits as to climate, and the feasibility of cultivation of various crops."

Many trees, as recorded among the great number of observations made by Dr. Bell, seem to permit themselves a wider diffusion by changing their habitat at different latitudes. For instance, the larch, balsam fir, and white birch grow in the north upon dry or hilly ground, while southward they seek wet and cold swamps. The white cedar and white pine show a similar tendency. Again, average temperature has less to do with the distribution of trees over a wide extent of country than the general character of uniformity in the climate of its various sections. In the west there are great extremes of heat and cold, and in the east milder winters and cooler summers, though the mean annual temperature remains about the same. This produces a great effect upon the growth of timber, and may account in a measure for the great difference in the character of the woods east and west. The moisture of the atmosphere is another important factor, great dryness of air exercising a very repressive influence upon forest growth. Fogs, cold winds, proximity of the sea, also affect the size and kinds of trees. Difference in the composition of soil has no such general influence as might have been presumed.

The North American continent, from the southern boundary of the United States to Hudson's Bay, contains about 340 different species of forest trees, of which about 90 flourish in the British possessions. The manner of distribution of the various trees varies exceedingly. Some are locally plentiful, others uniformly present over the entire area covered by the species, and yet others, though spread over a wide territory, are nowhere very common. The most northern species are the most extended, and the southern are more restricted. This, it is presumed, arises from the increasing diversity of climate in the lower latitudes in going from east to west, a change not so noticeable in the more northern regions.

"There is no material change in the woods throughout the great triangular area embracing about 600,000 square miles, of which the national boundary line between the Rocky Mountains and Lake Superior forms the base, and the Rocky Mountains and Laurentian Hills respectively the west and east sides, the apex being at the mouth of the Mackenzie River. In the southern part of this area a number of species are added to the kinds which everywhere throughout it make up the bulk of the forests, and again, few trees of any kind are found to the south of the North Saskatchewan; still making allowance for local peculiarities of condition, there is a remarkable uniformity in the timber of this enormous area. It includes, however, only a few species, of which the aspen, balsam poplar, and willows are more abundant toward the western, and the spruces, larch, balsam fir, and Banksian pine toward the eastern side of the area."

An inspection of the map accompanying Dr. Bell's report shows that lines marking the northern limits of about a dozen species turn southward when they reach the eastern boundary of Lake Winnipeg and Red River, and then the succeeding lines follow the same general tendency, as if the extension westward of all met some obstacle which deflected them southward. These species are white cedar, black ash, white pine, red pine, sugar maple, yellow birch, red oak, white ash, hemlock, beech, ironwood, red cedar, and white oak. It is not that beyond them the land is unoccupied until the open plains are reached; other trees occupy the region between their northern and western limits and the treeless prairies. But Dr. Bell argues that "had the great forests originally extended further west and been destroyed by fire or other causes, in comparatively recent times, we should have found the northern limits of these species continuing their general course to the prairie region, and ending abruptly there, instead of which they all curve gradually round in a more or less concentric fashion, and other trees occupy the intervening ground." Of course, this remark bears upon the ancient and classical dispute as to the origin of the great prairies.

The State of Minnesota occupies an interesting region, embracing the northern limit of many of the species of Ontario, the southern limit of the Arctic forms, the western and northwestern limits of the species crowding through Ontario and the northeastern States. Favoring protection, as of hills or spurs, throws the *line of limit* northward and depressions do the same.

Finally, forest trees east of the Rocky Mountains may be divided into four groups:

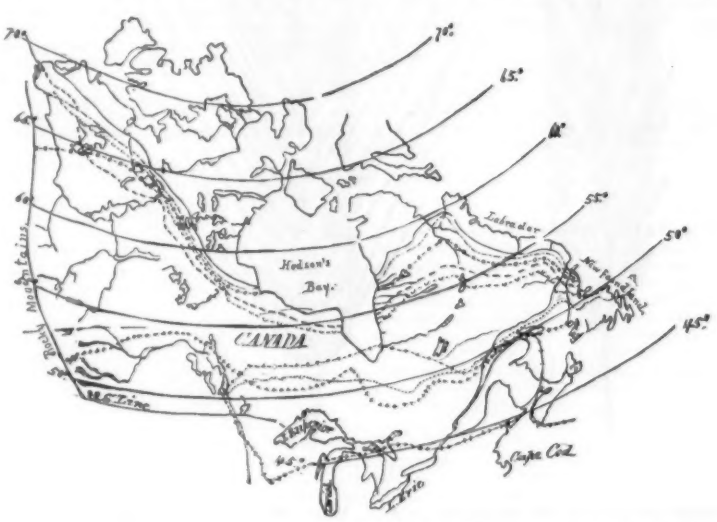
1. A northern group, including the white and black spruces, larch, Banksian pine, balsam fir, aspen, balsam poplar, canoe birch, willows, and alder.

2. A central group of about forty species, occupying the belt of country from the white pine line to that of the buttonwood.

3. A southern group, embracing the buttonwood, black walnut, the hickories, chestnut, tulip tree, prickly ash, sour gum, sassafrass, and flowering dogwood, which are found only in a small area in the southern part of Ontario.

4. A western group, consisting of the ash-leaved maple, burr oak, cottonwood, and green ash, which are scattered sparingly over the prairie and wooded regions west of Red River and Lake Winnipeg.

L. P. G.



Spruce
Aspen
American Larch
Canoe Birch
Balsam Poplar
White Elm
White Cedar
White and Red Pine
Red Cedar

MAP SHOWING THE GENERAL NORTHERN LIMITS OF A FEW OF THE PRINCIPAL FOREST TREES OF THE DOMINION OF CANADA.

Adapted from a more detailed map published in Geological Report of the Survey of Canada, 1881-82.

[NEW ENGLAND FARMER.]

POTASH FOR BARREN FRUIT TREES.

FRUIT trees are occasionally met with which, year after year, fail to bear fruit, or, if they bear any, only a small amount of inferior quality. The cause of such barrenness is sometimes difficult to determine. Generally, however, it will be found to be due to some defect in the soil, so that the tree fails to obtain some element of food without which it is impossible for it to bear fruit. This wanting element will often be found to be potash or phosphate of lime. By supplying what is lacking fruitfulness may be induced. A story is told of a printer's apprentice who sought to render fruitful several barren cherry trees upon his father's place. The trees, although not large in size, appeared unthrifty and in a dying condition. He thought that borers were at work on them, and not being familiar with the habits of these insects, imagined that they worked on the roots. He accordingly removed the earth from the roots about the trunk and freely applied a solution of caustic potash used in the printing office for washing type, which after becoming saturated with printer's ink was usually thrown away. The result was astonishing. The trees began to grow luxuriantly, and for years produced immense crops of excellent cherries. Although the treatment adopted by the young printer was suggested by a mistaken theory, yet it was evidently just what was needed in that case. The trees had been starved for the want of potash which the application supplied, and fruitfulness was the result.

Wood ashes, which contain a large per cent. of potash and considerable phosphate of lime, are excellent for use about fruit trees of all kinds. In case of barren trees, enough must be used to reach the feeding roots and furnish the needed amount. If only a few quarts are applied to each tree, the most if not all of the potash will be retained by the surface soil, and not reach the feeding roots of the tree. The ashes must be freely strewn about the tree, and if the tree is a large one several bushels may be used, but they should not be placed in contact with the trunk of the tree.

More than forty years ago there was standing in the vicinity of Homesdale, Pa., a pear tree so nearly dead that it was about to be cut down.

The mother of the owner having a partiality for the fruit of that tree, and thinking it might be suffering from worms at the roots, resolved to attempt its restoration to health. She had the earth removed from about the tree, uncovering the large roots, upon which she poured a large quantity of lye made from wood ashes. She had the excavation filled with leached ashes, and the dead limbs removed from the tree. The result was a most remarkable growth of wood, followed by great productiveness for nearly forty years. The application of the lye and ashes apparently supplied the food, for the want of which the tree was dying.

Near Bellefonte, Pa., there was, a few years ago, an immense pear tree, with a trunk two feet in diameter. The tree had been set seventy years, and for sixty years had not failed to produce a crop of fruit, while other trees of the same variety, planted at the same time, had died of old age several years before. This remarkable tree had always had by its side an ash leach, from which a considerable quantity of potash in the form of lye had escaped and found its way to the roots of the pear tree. Thus the potash had kept the tree alive, vigorous and productive during many years.

Those having pear and apple trees which are unproductive, should try the effect of a liberal application of wood ashes. There need be no fear of using too many, provided the ashes are spread over the surface of the ground, and not piled against the trunks of the trees. If the tree is a large one, three or four bushels will be none too much, and may be repeated every year, until the tree is made productive. Some may think so large a quantity of ashes might injure the tree, but an account was published a few years ago of an apple orchard in Chester County, Pa., which had borne a heavy crop of remarkably large and highly colored appies, every year, for twelve years, each tree of which received an annual application of about eight bushels of unleached ashes. If ashes are good to make barren trees productive, they are equally valuable to increase the productiveness of fruitful trees. If the productiveness of an orchard can be increased two or three fold by the use of ashes, it will well repay the owner to use them. Instead of having a crop of apples every other year, a crop every year might be obtained by liberally feeding the trees.

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Livermore Falls, Me.

THE English people are just now lamenting over the arrival in their midst of a new enemy. The *London Times* says that during the warm weather of the past week a number of persons in the north of London have been bitten by mosquitoes. Women and children have especially suffered, some having been almost blinded through the swellings caused by the bites of these foreign insects. It appears, continues the *Times*, that large numbers of mosquitoes were brought over from America among the corn, and they have been frequently seen to fly up when the grain is being transferred for grinding in a large steam flour mill in the vicinity.

[AMERICAN NATURALIST.]

PITCHER PLANTS.

By JOSEPH F. JAMES.

THERE are two widely separated orders of plants known by the common name of pitcher plants, and they are perhaps as widely separated in a natural classification as they are in their habitats. While one order is placed near the poppies and is a native of America, the other is allied to the birthworts or the Aristolochias, and lives in the swamps of Southeastern Asia, and the islands of the Malay archipelago. The first of these orders is known scientifically as Sarraceniaceæ, and includes but three genera; the other is Nepenthaceæ, with but one genus. Both of them are more or less familiar to persons interested in plants, and the latter always attracts attention by the peculiar appendage, like a bird's nest to the eyes of some, which is suspended from the tip of the leaf. It is to the first of these orders, the members of which are, with a solitary exception, natives of the United States, that this paper is devoted.

The genus Sarracenia, named in honor of Dr. Sarrazin, of Quebec, who first sent the plant and an account of it to Europe, comprises eight species, all but one of them being confined to the Southern States of our country. The one with the widest distribution, the well-known side-saddle flower, extends from near Florida, through the Atlantic Coast States to New England, and thence westward along the northern boundary of the country, and in Canada, into British America. It lives in the cold swamps and bogs of the North, and its peculiar leaves and flowers have always been remarked by those who have collected or have seen them. The inside of the hood of the leaf is covered with a closely set mass of hairs, in all cases pointing downward into the tube. In a state of nature these aptly named pitchers are often half filled with water; and the water is generally so crowded with insects, dying or dead, or decaying, that the air in a swamp where numbers of the plants are growing is very offensive.

At the junction of the hood to the main portion of the leaf, the hairs end abruptly, and the inside becomes very smooth and polished. This continues to about the middle of the pitcher, when another set of hairs is met with, this time not so stiff as at the top, but all of them still pointing downward toward the bottom.

This peculiar arrangement of a set of hairs at the apex of the leaf, of a smooth portion near the middle, and another set of hairs near the base, obviously serves some use in the economy of the plant. When the young leaves first open, there is no water found in them, but as they are so open and exposed to all rains and storms, they readily become partially filled with water. Now this soon becomes a mass of decayed animal matter. Insects fly or fall into the tube, and once in, there is no egress. The fringe of hairs at the base hinders their walking, and even if this be surmounted, and the smooth stretch passed, the hairs on the hood, a veritable *chevaux-de-frize*, stop his onward and upward progress. He loses his foothold among the many hairs and falls hopelessly back to the bottom, to be eventually either drowned or starved.

It has often been a matter of surprise to see the number of insects in these pitchers, and it is more notably so because there seems to be so little to take them there; so little to induce them to tumble into the trap spread for them. But in thinking the matter over and taking into consideration one or two curious coincidences, it has occurred to me that this may be explained as follows: The flower is of a peculiar structure, is nodding on a naked scape, and the stamens with their mass of pollen are concealed behind the broad, peltate stigma, which forms, in fact, a sort of reversed table. An observer, Mr. J. Jackson, Jr., has recorded (*Bot. Gaz.*, vi. p. 242) that in examining a number of flowers he has found the cavity between the inner surface of the stigma and the stamens to be filled with flies, apparently eating the pollen. Fourteen flies were counted on one flower, and were, as he states, "in no hurry to vacate the premises." The suggestion I would make is this: If we suppose that there is something in the pollen, or in some secretion of the flower which has the effect of stupefying or intoxicating the insect, a not improbable supposition, by any means, and then imagine a sharp wind shaking the flower vigorously, would not the tendency be to shake the flies from their hold, partially stupefied as they are? They would drop to the ground, or else into the pitchers opened below them. These in their turn are admirably adapted to catch falling insects, for the hood is upright, and the cavity of the leaf fully exposed. The leaves too are spread out in a sort of rosette, quite close together, and all so inclined as to bring the opening in the most favorable position to catch any falling object. What then is to prevent the leaf from securing its prey? And should it be so, it would be strange to find the flower used as a lure to bring food to the plant. It is said that a slight secretion has been detected about the orifice of the pitcher of this species, but Dr. Gray considers it to possess but little efficiency in securing the multitude of flies sometimes found in the pitchers. The sugestion here made is, I think, worthy of consideration, and will not appear so very improbable when we come to other facts in relation to our subject.

Turning now to another species, let us see what other facts can be learned, and see, too, what bearing they may have on the facts ascertained in regard to *Sarracenia purpurea*. The *Sarracenia flava* is a Southern species, extending from Virginia to Florida, and inhabiting the same swampy places which are the favorites with *S. purpurea*. The *flava* differs in a marked manner from the *purpurea*. The pitchers are much taller, stand more upright, and the lobe at the top is wider and more spreading. The inner surface of the hood has much smaller hairs, so small that it might be called a fine pubescence. But a still greater difference is found in the fact that there is a saccharine secretion found on the inner side of the hood, just above the junction of the lid with the rim. But there is something in regard to this secretion which is quite interesting. It has been stated by some observers, and it is thought with truth, that the secretion possesses intoxicating or stupefying qualities. As the insect feeds upon the matter it becomes dizzy, loses its hold on the surface of the hood, and falls to the bottom of the tube. Dr. Gray says in regard to this secretion at the orifice of the pitcher, (*Am. Jour. Sci. and Arts*, ser. iii., vol. vi, pp. 149–50) that "This made its appearance first in the form of minute drops, distinctly visible only under a lens; at length it forms flattened drops and even patches, distinctly sweetish to the taste and viscid to the touch." Mr. Brady, who observed the plants in North Carolina, says in regard to some pitchers of this species, "These, brought into the house, and kept fresh by the immersion of the base in water, showed the saccharine secretion most abundantly about a quarter of an inch above the junction of the lid with the rim. . . . Many flies settled on the lids and feasted on the saccharine narcotic. Evident signs of intoxication were manifested in each case, by their breaking loose repeatedly before tumbling into the gulfs." (*Am. Jour.*, ibid., p. 468.)

It is well known, as has been already noted, that the insects found in the leaves of *S. purpurea* meet their death by drowning, but with the *S. flava* the case is different. In regard to this Dr. Gray says (*Am J.*, ibid., pp. 149–50) "That the insects which abundantly fall or find their way into Sarracenia pitchers do not generally escape, but die and decompose there, is obvious. That more commonly they do not perish by drowning in *S. flava* is equally clear. While all the lower and gradually attenuated part of the tube is filled with dead flies in our plants growing in the house, there is only a little moisture at the very bottom. One would hardly think that the fine and sharp-deflexed bristles, which line the lower half of the tube only in *S. flava*, would greatly impede the return of a fly, they lie so closely against the wall of the tube. But I find that a house-fly, either large or small, when thrown into this lower part of the tube, is quite unable to get out, and there it perishes. Probably the advantage derived by the plants is equally secured, whether their prey decomposes in the moist air of the cavity or in the water in which they are often immersed."

This water, which is in the lower portion of the tube of *S. flava*, is also a secretion of the plants, for Dr. Gray and Mr. Canby found that "it distills in drops from the inner surface of the young pitcher before the orifice is open." (Ibid., p. 149). The amount becomes afterward greatly increased by the rain which falls without difficulty into it.

There is in a third species this same sort of a secretion, with apparently the same stupefying effects. This is the *Sarracenia drummondii;* it has upright leaves which sometimes grow to be three feet in length, and they are peculiarly mottled with white spots. The hood has much larger and more conspicuous hairs than in the former species, and it is on this hood that the secretion is formed. Dr. Chapman, in writing to Mr. Canby, says; "On the inside of the hood, above its junction with the tube, there is a very faintly sweetish secretion scarcely perceptible to the taste, which is very attractive to insects; and, as I do not detect any of this within the tube, I wonder how it happens that so many insects are entrapped, since they could easily fly away from the open hood." (*Am. Jour.*, ibid., p. 468.) Here again the stupefying qualities of this secretion are manifested, for it is after the insects have partaken of it that they are unable to fly away, and so fall into the trap.

Is there not good reason then for the theory I have advanced in regard to some stupefying matter in the flowers of *S. purpurea?* If the secretions of two species have poisonous properties, why should not that of a third have the same power? especially when it probably serves the same end in the economy of the plant, namely, that of providing insect food for it.

We come now to another species of the curious genus, the facts in regard to which are still more wonderful than those already given. This species is the *Sarracenia variolaris*, an inhabitant of the "damp pine lands," flourishing best on the edges of "pine-barren ponds" of Carolina and other Southern States. It differs in a marked manner from the other species noticed inasmuch as the hood, instead of standing upright and leaving the orifice of the picture exposed, is bent over and shuts out most effectually any rain that may happen to fall. According to an excellent observer, Dr Mellichamp of South Carolina (Pro. A. A. Adv. Sci., vol. xxiii, 1874) the leaf may be divided into three portions: "First the inner surface of the hood or upper lid, marked on the posterior portion by white translucent spots and purple reticulations, which last extend forward and upward, and again downward of each side of the rim, for [supposing the leaf to be a foot long] a half an inch or sometimes an inch." This embraces the internal honey-bearing portion. "Immediately below this and extending for the space of three inches, there is an exquisitely soft and velvety pubescence, which under the glass is seen to be composed of very fine and thickly disposed retrorse hairs. This may be termed the second belt, and is so smooth as to afford no foothold for most insects. Below this again the eye may detect a deeper colored pubescence, of a pale yellow or straw color, still smooth, but composed of coarse hairs, which became longer and more bristly as the tube narrows. At the base of this tube a watery fluid is secreted, into which insects are precipitated. This is the third belt, and about five inches in length."

Examination of numbers of the young leaves, into which it was impossible for the rain to have found its way, revealed the fact that almost invariably there was some liquid to be found. This was sometimes but a few drops and at others as much as a drachm or even more. Experiments with this fluid brought to light some interesting facts. By great care the experimenter collected about a half ounce of the liquid and experimented chiefly with house flies. I give the results in his own words: "About a half drachm of the liquid was placed in a small receptacle, and the flies thrown from time to time, the liquor not being deep enough to immerse them completely, but enabling them to walk about in it without the risk of being drowned. Perhaps twenty flies were experimented with. At first the fly makes an effort to escape, though apparently he never uses his wings in doing so, the fluid, though not very tenacious, seems quickly to saturate them, and so clings to them and clogs them as to render flight impossible. A fly when thrown into pure water is very apt to escape, as the fluid will 'run' from its wings, but none of these escape from the bath of the Sarracenia secretions. In their efforts to escape, they soon get unsteady in their movements, and tumble, sometimes, on their backs; recovering, they make more active and frantic efforts, but very quickly stupor seems to overtake them, and they turn on their sides either dead (as I at first supposed) or in profound anæsthesia.

"I had no doubt, from the complete cessation of motion, and from their soaked and saturated condition, that they were dead, and like dead men they were 'laid out,' from time to time as they succumbed to the powerful liquor; but to my great surprise, after a longer or shorter interval, from a half hour to an hour or more, they indicated signs of returning life, by slight motions of the legs and body. Their recovery was very gradual, and eventually, when they crawled away, they seemed badly crippled and worsted by their Circean bath. After contact with the liquid, the flies first thrown in became still seemingly dead, in about a half minute; but whether from exposure to the air or exhausted by action on these insects, the liquor did not seem to be so intoxicating with those last exposed to its influence. Anæsthesia or intoxication did not occur so quickly; it took from three to five minutes generally, and in one rebellious 'subject' it was at least ten minutes before he received his *coup de grace*. A cockroach thrown in succumbed almost immediately, as did also a small moth and much more slowly a common house-spider. On the recovery of the latter it was almost painful to witness his unsteady motions. Without doubt, therefore, the secretion found in the tubes of *Sarracenia variolaris* is intoxicating, or narcotic, or anæsthetic, or by whatever word we may prefer indicate that condition to which these small insects succumbed."

To still futher test the qualities of this fluid, Dr. Mellichamp placed bits of venison in some of the Sarracenia secretion and some in pure water, and he found that in the former at the end of fifteen hours the meat was much more decomposed and gave out a much more offensive odor than in the latter; thus proving that the secretion possessed powers of decomposition.

Turning his attention then to the secretion on the hood of the pitchers, the observer found that it was best developed in warm weather, covering from a half to an inch of the surface. But he also found what has not been found on any of the other species, "a continuation of the sugary exudation . . . glistening and somewhat viscid along the whole border or edging of the 'wing'—extending from the cleft in the lower lip even to the ground. There is, therefore, a honey-baited pathway leading directly from the ground itself up to the mouth, where it extends on each side as far as the 'commissures' of the lips, from which it runs within and downward, as before stated, for at least half an inch."

This exudation is not, it must be understood, an exceptional thing, but it is invariably found on leaves which are sufficiently mature and favorably placed in regard to the sunlight and moisture. And as showing the extensive use of this baited pathway, it is stated that ants, those prowling insects ever on the search for prey, are most frequently to be found in the pitchers. Further, it should be stated that this honey pathway does not seem at all to possess the anæsthetic qualities of the secretion at the bottom of the tube, but it simply acts as a lure. The flies would eat along the pathway and then enter the tube, either along the inner face of the hood or at the lower side. "After entering (which they usually do with great caution and circumspection apparently), they begin again to feed, but their foothold for some reason or other seems insecure, and they occasionally slip . . . upon this exquisitely soft and velvety 'declining pubescence.' . . . I have seen them," he continues, "regain their foothold after slipping, and continue to sip, but always moving slowly, and with apparent caution, as if aware that that they were treading on dangerous ground." When attempting to fly they either strike against the hood, or the sides of the tube and keep falling lower and lower until they reach the liquid at the bottom, where they become asphyxiated and at last take the form of the liquid manure which is utilized by the plant. Other experiments seem to show conclusively that the honey of the lure possesses no intoxicating qualities, and that it is owing to the peculiar pubescence on the inside of the tube, which prevents the insect from making its way out by crawling.

For instance, some of the tubes were split open their whole length and smeared with the honey. Then they were placed flat on the table, and a fly which had been smeared with the secretion so it could not fly was placed upon the pubescent part of the tube. Mark the result: "The fly immediately made an effort to advance, but to my great surprise its most vigorous and persistent efforts availed nothing, as it slowly but steadily retrograded to the lower extremity of the tube! The experiment was repeated frequently, but always with the same result. It was as if a boat with insufficient propulsive power were steadily drifted back by a strong tide, only in this instance the tide seemed to be the polished retrorse hairs, made still more slippery by the fluid, with which also the insect was covered."

But while the large majority of the insects which are found in the pitchers of *S. variolaris* are there to die, there are two, a moth and a fly, which live there almost altogether. These have some peculiar modification of the hairs on the legs which enables them to surmount the peculiar pubescent surface. These insects are, of course, there only for the purpose of rearing their young, for they deposit their eggs, and the larvæ of one feeds on the decayed matter in the pitcher, and of the other upon the tissues of the leaf itself.

We have seen in the contrivances of these four species of Sarracenia, a great diversity in order to secure the same end. That end will be evident with but little consideration. It must be for the nutriment of the plant in some way. When we study the Venus fly-trap, or the sun dew, we know that there is some benefit derived from the insect prey they capture. When we see the many marvelous contrivances in the flowers of the orchids, machinery arranged for the sole purpose of producing seed, we do not for a moment consider it chance, but know there is an adaptation of means to an end. And so, when we find in the pitchers of the species of this genus, such obvious traps for insects, we may feel assured that they are for some use. They can only be to supply the plant with nourishment, either as a liquid manure for the roots, transmitted through the cells at the base of the leaf, or else by some absorbent glands, which take the matter directly into the tissues of the plant. The probabilities are in favor of the former, for while large tubular cells have been noticed passing down through the base of the petiole into the root (Pro. A. A. A. S., vol. xxiii., 1874, Nat. Hist., p. 25), there have not been found, I believe, any absorbent glands on the interior surface of the leaf. It is very likely, as has been suggested, that as we find the leaves of Dionœa becomes less sensitive after a time, and cease to absorb matter, so the leaves of Sarracenia contain much more decaying matter than suffices for their use. This is made use of by various insects, for larvæ of different kinds are found in old pitchers, especially those of the *S. purpurea*. And birds are known to split open many of the pitchers and devour the insects inclosed. Finally, as Dr. Hooker says (Address before Brit. A. A. S., 1884, *Nature*, vol. x., p. 370), "the pitchers decay, and part, at any rate, of their contents must supply some nutriment to the plant by fertilizing the ground in which it grows."

Taking leave now of the genus Sarracenia, let us turn to another genus of the same family, the Darlingtonia, of a still more curious structure. This plant inhabits the bogs of California at an elevation of from 6,000 to 7,000 feet, and is limited to a very few localities. It was discovered as long ago as 1842, but it is so scarce and so few people have had an opportunity of observing it in a state of nature, that we know comparatively little about its structure and habits. What we do know is due to the observations of Mr. J. G. Lemmon and Mrs. R. M. Austin, of California, and to Mr. Canby, who has published an account of the plant. The tubular leaf is quite long, stands nearly upright, and has a peculiar twist, which no other species has. The hood, instead of being open as in *S. purpurea*, or simply covering the opening, is a vaulted arch, projecting over so far that the only entrance to the tube, in the largest leaves about an

inch in diameter, is immediately beneath. In front of this opening are two very peculiar appendages, spreading out on each side, and likened to a fish-tail, or a butterfly's wing. The top of the arch and the upper part of the tube are spotted in a peculiar manner with white spots.

This plant, like the others, secretes a sugary matter on the inside of the peculiar projections, which are also covered with bristles. And this sugary secretion, as in the *S variolaris*, extends from the orifice, down the wing to the ground. The insects which are principally found in these tubes are flies, moths, etc., and in attracting these the peculiar fish-like projections are doubtless of great use. Besides being conspicuous for their size, they are brightly colored and peculiarly mottled. The moth, attracted by the conspicuous appendages, alights and feeds on the honey. Entering the tube, as it is almost sure to do, and afterward attempting to escape, it is prevented by the over-arching hood and falls into the tube. Here it finds the same sort of hairs described in Sarracenia, and is wedged deeper and deeper into the tube, to be finally drowned in the fluid secreted at the bottom. The peculiar twist is probably to wedge the insect more firmly into the tube, and make it more impossible than ever for it to find its way to the top. The peculiar white spots on the arch, and at the back, are supposed to be for the purpose of misleading the insect. The sun-light striking through them would make it appear a more conspicuous opening than the real one below, and by striking their heads against these simulated skylights they would be more likely to be knocked into the tube.

The flowers are solitary at the top of a bracted scape, of the color of the flap of the pitcher, and the organs are arranged in such a manner as to entirely prevent its being fertilized except by the aid of insects. Dr. Hooker, in speaking of these flowers, remarks that he was struck "with a remarkable analogy between the arrangement and coloring of the parts of the leaf and of the flower. The petals are of the same color as the flap of the pitcher, and between each pair of petals is a hole (formed by a notch in the opposed margins of each), leading to the stamens and stigma. Turning to the pitcher, the relation of its flap to its entrance is somewhat similar. Now, we know that colored petals are specially attractive organs, and that the object of their color is to bring insects to feed on the pollen or nectar, and in this case by means of the hole to fertilize the flower; and that the object of the flap and its sugar is also to attract insects, but with a very different result, cannot be doubted. It is hence conceivable that this plant lures insects to its flowers for one object, and feeds them while it uses them to fertilize itself, and that, this accomplished, some of its benefactors are thereafter lured to its pitchers for the sake of feeding itself!" (*Nature*, vol. x., 1874, p. 370.)

Who can deny now that we have not to deal here with a marvelous order of plants? Every member of it has some peculiar feature, and the means used to accomplish the same end is a striking instance of the diversity in nature. While in one species it is a poisonous honey which intoxicates the insect and causes it to fall into the tube, in another it is, perhaps, a poisonous secretion of the flower, which answers the same purpose; in a third, it is a baited pathway which lures the insect to destruction, and a stupefying liquid which decomposes the bodies of the same; and in a fourth, it is the simulation of the wings of an insect, as well as honey and a baited pathway, which attracts the prey. What doubt can there be, but that all these contrivances subserve the same end? And when, too, we consider the curious relation between the flower and the leaf in Darlingtonia, and the very different shape of the flower in Sarracenia, we see there must be still other facts to be discovered. Such an abnormal stigma as is possessed by the Sarracenia cannot but be of some use. With its broad, flat, table like expansion, most effectually concealing the stamens behind it, it is utterly incapable of self-fertilization. There must be some relation between it and the leaves, but what this is, is at present a mystery. Then to trace the evolution of the leaves from the normal shape to the present peculiar one, would be of interest, but space forbids, and leaving this matter for some future time, we take leave of this fascinating subject.

LIFE-HISTORY OF THE LIVER-FLUKE.

PROF. A. P. THOMAS, now of Auckland, New Zealand, has published in full the results of his valuable and important researches on the development of the liver-parasites, which produce the so-called "rot"—a disease that is especially fatal to sheep, but sometimes occurs in man. It is estimated to have occasioned the loss of some 3,000,000 sheep in Great Britain during the winter of 1879–80. Leuckart has also studied this subject, and reported his observations in the *Zoologischen Anzeiger* for October 9, 1882. Thomas' results, as given in the *Quarterly Journal of Microscopical Science* for January, 1883, are remarkably complete; and, as they are of general interest, we present an abstract of them.

The adult worm (Distomum hepaticum) infests the liver of mammals. It discharges its eggs into the bile-ducts, which they sometimes clog. The eggs then pass into the intestines, and may be found abundantly in the droppings of the host. The number of eggs emitted by a single fluke may be safely estimated at several hundred thousand. Segmentation of the ovum occurs in the body of the host; but the further development being dependent on a lower temperature than that of the mammalian body, and on moisture, can proceed only after the eggs are discharged. 23°–26° C. is most favorable, the embryo being formed in about three weeks. At a lower temperature, the development is prolonged; but, under the same conditions, the individual eggs vary enormously as to the time needed to produce the embryos: hence a field once infested remains dangerous for a long time. The embryo enlarges at the expense of the nutritive material (so-called *yolk-cells*, though they have nothing to do with the yolk) and, when mature, bursts open the operculum of the egg-shell, and immediately begins swimming freely in the water. Its form is an elongated cone (0·13 mm. long), with rounded apex, as is shown in Fig. A of the accompanying cut. The base of the cone is directed forward, and in its center is a short tractile head papilla, *pr*. The whole surface is covered with cilia, which are borne by the large octodermal cells. In the interior are *two* eyes, *oc*, and other structures, which are very briefly described, and call for further study. The embryo is exceedingly active, swimming about like an infusorian, though more rapidly. When it meets a *Lymnæus truncatulus* (a common snail), its first host, it presses the head papilla against the surface of the snail, and begins spinning around its axis, and working its body, until the tissues of the snail are forced apart, leaving a gap through which the embryo squeezes its way into its host. The embryo appears to have some means of instinctively recognizing the *truncatulus*, for it does not attack other species. It cannot live much more than about twelve hours in water, and it usually gets into a snail within eight hours.

In the snail it changes into a sporocyst, which, during warm summer weather, may reach its full size within a fortnight; but in autumn twice that time may be necessary. The outer ciliated cells swell up, and are finally cast off. The embryo then becomes an elliptical cyst, the pigmented eye-spots being still preserved, Fig. E. The cyst grows and elongates. The body is then covered by an external cuticle, under which is a sparse musculature, followed by an epithelium, which lines the cavity, and forms the greater part of the thickness of the body-walls. The author gives some further structural details. Sometimes, but less frequently than in other species, these sporocysts multiply by transverse division, effected by a gradually deepening constriction about the middle of the body.

The next larval forms, the rediæ, are developed within the sporocyst. The cells, which each give rise to a redia, are in part soon present in the embryo; but they increase later by proliferation of the cells lining the cavity of the sporocyst. The first clearly recognized appearance of the rediæ is as a morula-like cluster of cells, which soon assumes the gastrula form. An external membrane appears, and, later, a pharynx. There are several germs in each cyst, usually one redia (less frequently two) nearly ready to leave the sporocyst, with two or three germs of medium size, and several small ones, Fig. B. When ready to leave the cyst, the redia, by its own motions, makes a forcible exit by rupturing the walls of the sporocyst. The free rediæ force their way through the tissues of the host, and are found especially in the liver. They increase in length to 1·3 mm. or 1·6 mm., Fig. C; a collar, *q*, being formed, meanwhile, a little behind the pharynx. In other respects, except the possession of a digestive tract, the rediæ resemble the sporocysts in structure. They are, however, more muscular, and present other differences, which the author describes. There is present a distinct birth-opening at the side of the body, a little behind the collar, which permits the exit of the brood from within the redia. The germs, *sp*, develop similarly to those of the sporocysts, but are more numerous. Sometimes they form rediæ, and sometimes cercariæ; yet the early stages of the spores are the same in either case. A germinal cell, forming part of the internal lining of the posterior end of the body-segments, forms a morula. A gastrula enlarges, and gradually assumes a shape that reveals whether it shall become another redia, or a cercaria. There may be as many as twenty-three spores in various stages of development in one redia. It is probably the temperature which determines whether rediæ or cercariæ are produced; since the former are produced during the warm, the latter during the cold months.

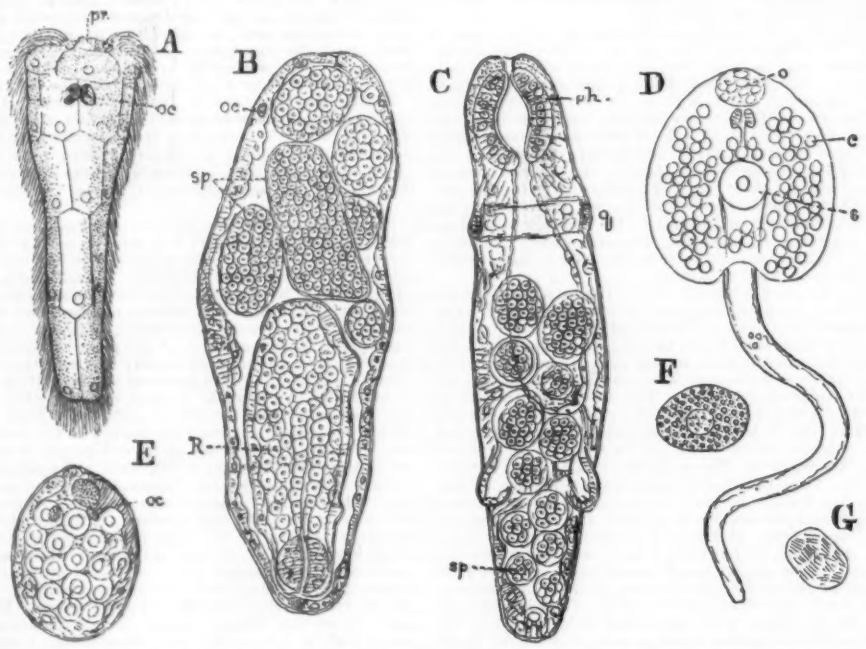
The development of the cercaria, the next form in the series, takes place, as we have seen, in the redia. As the oval enterate spore increases in size, it assumes a more elongated shape; while one end becomes more attenuated than the other, and finally is constricted off to form the tail. The thicker portion becomes the body proper, and in it are developed the bifurcate intestine and other organs. Certain cells, F, later develop into the organs for secreting the cyst; and many of the cells in the body of the cercaria are crowded with most remarkable rod-shaped bodies, G, closely resembling bacteria in size and shape, reaching a length of 0·006 mm. In an adult redia, with a brood of twenty or so, there will be one, two, or three cercariæ approaching complete development.

As soon as the cercaria has reached the limit of development within the redia, it escapes from the parent by the birth opening. When free, D, the cercaria is very active, and constantly changes its form. Its most striking characteristic is the presence of the cystogenous cells, D, *c*, before mentioned. These are large and so crowded with coarse, highly refractile granules as to be rendered quite opaque, F. They are arranged in two-lobed masses, extending along each side of the body, and connected together just in front of the ventral sucker.

By the aid of its suckers, *o* and *s*, and tail, tad-pole shaped cercaria crawls or wriggles its way out of its host. When the infested snails are kept in an aquarium, the cercariæ may occasionally be found swimming about in the water, but not long; for, on coming in contact with the side of the aquarium or the water-plants, it proceeds to encyst itself. The process can be readily observed under the microscope; for on a glass slide the cercaria soon comes to rest. It assumes a rounded form; while a mucous substance is poured forth all over the body, together with the granules of the cystogenous cells. The tail is shaken off either before or during encystation, which is completed in a few minutes.

These cysts are the means of infecting the final vertebrate host of the parasites: the infection being rendered possible by the habits of the intermediate host, *Lymnæus truncatulus*, which might well be termed amphibious, so strongly is its habit of wandering on land developed. Indeed, they can remain on land for long periods, and resist even prolonged droughts; hence, when in the water the snails become infested, and, when on land, leave the cercariæ that crawl out of their first host scattered over the fields, where they encyst on the grass, and are eaten by the sheep and other animals.

In the stomach the cyst is dissolved, leaving the worm free. The worm then makes his way into the liver, and probably in about six weeks begins to produce eggs, growing meanwhile. During its growth its external form changes, the simple forked intestine develops many cœca, the posterior sucker is greatly enlarged, and the sexual organs are matured. Thereafter, the wondrous cycle of metamorphoses and emigration recommences with the new eggs. There are, perhaps, no other instances more striking of the adaptation of animal species to particular conditions of existence than we find in histories of such parasites as the trematode worms, of which we have narrated one life-history.—*Charles S. Minot, in Science.*



EXPLANATION OF FIGURES.—A, embryo; B, sporocyst; C, redia; D, cercaria; E, young sporocyst; F, cystogenous cell; G, pod cell from cercaria. *oc*, ocelli; *sp*, spores; *R*, redia; *ph*, pharynx; *q*, collar of redia; *c*, cystogenous cells; *s*, sucker.

[KANSAS CITY REVIEW.]

TRUE TIME TAKEN AT KANSAS CITY BY REGULAR STELLAR OBSERVATIONS.

By W. W. ALEXANDER.

IN order to obtain time we must have a starting point, something must be noted, and its return or repetition again noted. To have our time perfectly equable or uniform in its increase, this event must be certain and regular. Then we can avail ourselves of some mechanical means to subdivide this interval into equal parts; this is what our watches and clocks are intended to do, but they must have something to start from and also to regulate their rate of speed; if not, one will gain, another lose, or if two should agree, both may be wrong, for a chronometer, no matter how well made, will after a long lapse of time show a variation in its rate of motion. For the benefit of the public, I will here explain the method adopted by astronomers: It is to watch the daily rotation of the earth, which presents us with a beautiful and accurate time signal, in fact it is the only regular and constant motion known; it has been watched by astronomers for centuries past, and not a fraction of variation found (this regularity is of infinite value to them in determining the eccentricity of other celestial bodies), so they have adopted this rotation as the base to measure the flow of time. In order to use it, some stationary point must be found outside and separate from the earth. The fixed stars filled this want, but what one to use was the next question, there being over 300,000 visible. It was finally agreed by astronomers to use the first point of Aries, or the intersection of the equator and the ecliptic at the vernal equinox for the commencement of the sidereal day. From the time a meridian leaves this point until it returns is twenty-four hours, or one day sidereal time; the hours are divided into minutes and seconds. Watching our meridian move eastward across the heavens, all the stars are found to be crossed by it; the interval from the time this day began until the star is on the meridian is called the "right ascension," or sidereal time of its meridian passage. The right ascension of our 300 stars known as the "standard time stars," has been determined with all attainable precision. The greatest variation, if any, cannot exceed the tenth part of a second in time; they are distributed all the way round the circle of the heavens at intervals of about five minutes for convenience of observers who require accurate time at all hours of the night; the brightest can be observed even in daylight, so at all times they are available (if the sky be clear) without much delay. A catalogue of them is published every year by the United States Naval Observatory, Washington, for the use of American astronomers and navigators.

All that is necessary in order to set and regulate a time-

piece is a transit instrument adjusted, collimated, or placed at a right angle with its axis, and set to swing north and south, the axis being level. The one I have in use here is a two and three-quarter inch aperture achromatic of forty-eight inches focus, magnifying seventy-five diameters; have it in fine adjustment and set in the meridian, stars observed south and north of the zenith agree in time to a fraction of a second. This proves it to be in the meridian and the time correct. The passage of the star is observed at five equidistant vertical wires, two on each side of the meridian wire on line. The instant at which the star is bisected by each wire is noted in a new chronograph, a very ingenious machine that works on the following principle:

A round disk of paper placed upon a horizontal block of wood four inches in diameter, is made by accurately running clock work to turn around once in a minute of sidereal time, or nearly so (a slight variation may be corrected). A needle point is arranged a short distance above the moving disk, which, simultaneously with the pressing of the spring, makes a hole in the paper and readjusts itself in position in less than the hundredth part of a second. At each round of the disk, the needle point moves in toward the center of the paper the sixteenth part of an inch, which prevents confusion in distinguishing the punches. To illustrate its use, take the transit of Procyon, April 10, 1883. From the catalogue of stars I found that at 7 h. 33 m. 12·17 s., Procyon would be on the meridian. So at about three minutes before that time I arranged and placed the disk of paper in position and started the chronograph running, went to the clock I wished to time and watched it until it indicated 7 h. 31 m. 0 s., exactly, then touched the spring which marks the paper, carried it to the transit, and, simultaneously with the star's passing the first vertical wire, I again pressed the spring, and at the second, third, and so on until the five were passed, then removed the disk of paper and placed it on the reading dial, which showed by the relative position of the marks the interval from the time of the mark made at the clock to those made at the transit.

In the above observation the time noted was as follows:

	Min.	Sec.
First wire	1	46·2
Second wire	2	00·3
Meridian wire	2	14·4
Fourth wire	2	28·6
Fifth wire	2	42·6
	11	12·1
Mean of the five wires	2	14·2

The mean of all the wires corrects the error in observation at the central or meridian wire. In the above 2′ 14·14″ was the observed time at the central wire, 2′ 14·42″ as the mean of all the time noted at the different wires. This was the time that had passed 7 h. 31′ 00″ by the clock, add the two given 7 h. 33′ 14·42″, the time by the clock at which the star was on the meridian. True time of meridian passage from catalogue, 7 h. 33′ 12·17″, clock fast 2¼″, or the difference between the observed and the true time. Observations made on seven other stars all agree within 0·3″. This proves the time without doubt to be within that limit of error.

Time is something everybody should know; there is but one true mean and sidereal time to each meridian. Mean solar time, or, as it is commonly called, mean time, is the one in ordinary use, the one clocks and watches are intended to keep. It is perfectly equal in its increase, and is measured by the motion of a fictitious sun called a mean sun, that is supposed to move in the celestial equator with a uniform velocity. This mean sun is supposed to keep, on the average, as near the real sun as is consistent with perfect uniformity of motion; it is sometimes in advance of it, and sometimes behind it, the greatest deviation being about six minutes. This error in the time taken from the sun is called the "equation of time," and was found from the accuracy of sidereal time, which can be converted into mean time at any hour of the day. Time varies as we go east or west. In this latitude the difference is a trifle less than four seconds to the mile. So the time at the eastern limits of our city will be ten seconds faster than at the bank of the Kaw River.

The transit is placed in the rear of No. 1,416 Holmes Street, in west longitude 1 hour 10 minutes 08·0 seconds from Washington. The time there obtained is reduced to the meridian of Main Street, at the intersection of Seventh, by subtracting 1·7 seconds. A clock indicating this time (*i. e.*, mean solar, commonly called "city time") can be seen at No. 16 East Seventh Street, where corrections will be kept as near as possible by conveying the time with a pocket chronometer. The time thus conveyed will always be reliable within one or two seconds. Persons wishing it more correct are invited to call (on any clear evening) and see observations made with transit. Time observations at Kansas City will be a regular and permanent thing, and are intended mainly for the benefit of the public.

Kansas City, April, 1883.

COLLECTION OF SHOES AT THE MUSEUM OF CLUNY, PARIS.

THERE has recently been exhibited at the Museum of Cluny the famous collection of shoes recently purchased by Mr. Du Sommerard from the heirs of Mr. Jules Jacquemart, the distinguished engraver. The few selections we have made from these 310 specimens will only give a faint idea of the wealth and variety of the collection. We will note them rapidly:

EUROPE.

1. Woman's shoe, having a red heel, almost round, and formed of leaves of leather embossed and embroidered with silk. This heel is connected with the toe of the shoe by a secondary sole, which sole is flat and square at the end, and red in color. This shoe of white skin has a long flap on the top, and is cut out in such a way as to form wide strips on both sides which lace over the instep at the central flap. It is embroidered with borders and roses of pink silk, and at one time belonged to the wardrobe of Catharine de' Medici.

2. This patten shoe is of wood and is mounted on two supports trimmed with iron; the transverse piece is of leather embroidered with silk.

3. Man's shoe, of German manufacture, and of the sixteenth century, made of leather of a single piece, very high at the heel and quite open in front. The shoe is peculiar for the two points which terminate the shoe on each side.

4. A silk slipper plaited with yellow ribbons, formerly in possession of the Princess Lamballe.

5. Child's shoe, of Flemish origin, of the time of Louis XIII., in yellow morocco. The point, the heel, and the band are red.

6. High lady's patten shoe, with the upper portion of white leather, embossed and cut out ornamentally. Such shoes as these were worn by the Venetian court ladies of the sixteenth century.

7. Peasant's shoe, of the time of Louis XIV., of double thickness of leather, with enormous soles extending beyond the shoes, and with flaps at the sides which are fastened together over the instep.

8. French boot of the sixteenth century, with very large upper ornamented with fleurs de lis in relief; the foot of the boot being very small and quite rounded at the tip.

9. Heavy boot, of the reign of Louis XIV., called "the caldron," with a round, thick leg, and a square tip.

10. Lady's slipper, of the period of Louis XV., having a white heel and the upper made of embroidered silk, with pieces of stamped velvet of two colors, violet and black, inserted thereon.

11. Child's shoe of embroidered sky blue silk of the time of Louis XV., with a rose colored border, over which passes a strip of silver lace; the flaps are tied down by a shadowed pink ribbon.

12. A shoe, formerly the property of Henri de Montmorency, who was decapitated at Toulouse in 1632. This shoe is made of black leather, very long, with a square flat toe; it is ornamented with little pointed pads and with a large fleur de lis on the top of the foot. On the band are the initials of the duke. The heel is very high and is of wood, covered over with red leather.

14. Boot for postilion, of French make, period of Louis XV.

15. Boot with a stiff leg, time of Louis XIV., having a turned over top and a square toe.

TURKEY.

16. Patten shoe for the bath, made at Constantinople, very high, and made of wood veneered with pieces of diamond-shaped mother of pearl and strips of tin; the band is of violet cloth embroidered with silver.

17. Man's slipper, from Constantinople, having cut-out flower work *applique*, with a background of red velvet.

18. Sandal of Turkish lady, covered over with silver plaques, ornamented with work in relief.

19. Turkish slipper of white leather, made in the form of a boat, and decorated in front and at the back with bows of white and pink silk.

AFRICA.

20. Small boot of proper size for lady, made at Alexandria, of yellow leather, the upper portion being inserted within a slipper of suitable size having a pointed toe.

21. African slipper, of yellow leather, embroidered with figures in different colored silks which surround crescents that are embroidered in silver.

CHINA AND JAPAN.

22. Man's shoe, of Chinese make, of violet silk with a border of black satin.

23. Small shoe for woman, with a white satin sole and red silk upper with a little butterfly embroidered upon the toe.

24. Man's shoe made in Hong Kong, mounted upon a high patten of wood painted black. This patten is covered with a strip of red varnished leather which incloses the feet.

25. A shoe of Chinese fabrication for lady with small feet, having a white heel, and a black satin upper trimmed with white.

INDIA.

26. Shoe from British India, embroidered with flutings on the upper of the shoe, the portion turned over being red in color.

27. Patten shoe from India, raised upon a high leather sole, rounded in front, in the form of an epaulet, and trimmed with different colored satins; bands are provided for holding the shoe to the foot.

28. This shoe was made in the Punjab in British India; it is long in shape and laden with embroidery work in silver.

29. Wooden patten shoe from India, very peculiar in shape, and covered with engraved ornaments.

AMERICA.

30. Ancient war moccasin of the North American Indians, made of one piece of skin with designs embroidered upon it in red.

31. Very old moccasin for a child, North America; the skin is folded in plaits in front.

32. Moccasin for woman, of yellow skin embroidered with designs in different colored silks, having a strip of blue cotton cloth around the upper of the shoe, to which are attached orange leather thongs to protect the legs.—*L'Illustration.*

CURIOUS COLLECTION OF SHOES IN THE MUSEUM OF CLUNY.

SCIENTIFIC SHOWS.

THE ISOLATED BUST.

In the tricks of the living half-woman and the decapitated talking persons that we have already described, the body of the woman and the head of the decapitated person rested upon a table or upon a disk, and were consequently connected either with the floor, through the table legs, or with the ceiling, through chains. But just suppose such a half-body or such a head to appear isolated in the center of a bare stage, at several feet from the floor, ceiling, back, and sides and then just suppose it to be living, and we may well imagine what a surprise the illusion must create among the spectators. The bust may be either that of Socrates or that of a clown. Robert Houdin, the elder, was the first to exhibit this trick, and a side show at a country fair was the second. The isolated bust shown in the annexed cut is that of a clown, whose whitened face and white clothing are submitted to a strong light, and put in relief through the dark hangings of the stage.

The illusion is due to the effect of properly arranged mirrors.

FIG. 1.—THE ISOLATED BUST.

In our explanatory cut (Fig. 2), representing a vertical section of the stage, the line, PM, is a section of a large mirror, which, starting from the line of the curtain, P, runs to the back part of the stage at M. This mirrow is of the same width as the stage. At about its center it has an aperture through which a properly costumed actor may pass the upper part of his body, the edges of the aperture being hidden by the folds of his clothing. The mirror, then, divides the stage into two nearly equal parts, one of which, the front, is visible to the spectators, and the other, the back, invisible, and containing the actor's body. Now, the spectators are unaware of any such separation, and think that they are looking directly at the floor and back of the stage, while, in fact, they see but a reflection of the ceiling in the mirror.

In order to obtain such a result the mirror, P M, must make with the line of the ceiling, M *l*, an angle equal to that which it makes with the line of the back, M L, or, in other words, the line of the mirror, P M, must be the bisector of the angle, *l* M L.

Now, by virtue of the optical law that "an object reflected from a mirror appears to be behind the latter at a distance equal to that which separates it from it," every point of the line, M *l*, reflected from the mirror, P M, will appear to be situated upon the line, M L.

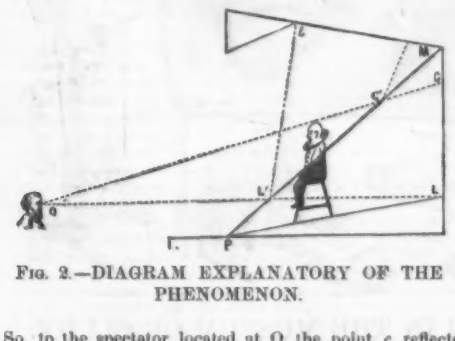


FIG. 2.—DIAGRAM EXPLANATORY OF THE PHENOMENON.

So, to the spectator located at O, the point, *c*, reflected at C' will appear to be the point, C, the distance, *c* C', equaling C C'. The point, *l*, reflected at L', will appear to be L. And it will be the same for all the intermediate points. The spectator, then, will believe that he sees the line, M L, when in reality he sees only the reflection of M *l*. Now, as we have just said, he will believe that he sees the back of the stage, when, in fact, he sees nothing but a reflection of the ceiling in the mirror. In the same way, the reflection from the front of the ceiling will produce the illusion of the stage floor. This fact still further contributes to increase the illusion, for the spectators are not aware of the difference that exists between the arrangement of the place where the bust appears and of that of the place where the showman is walking.

As the isolated bust should be exhibited only for a few minutes, in order that the interest in it may be preserved, and as it takes some time and requires care to arrange the apparatus, it is better adapted to cabinets of physics, and to booths at fairs where the audience is constantly changing, than to large theaters. But, under such circumstances, when the arrangements are well made, and the lighting properly regulated, it forms one of the prettiest and most interesting of optical illusions.—*La Nature.*

LONGITUDE.*

SEVERAL methods are given in the lecture for ascertaining the difference in longitude between any two points on the earth's surface, which is simply the difference between their local times, as determined at each place independently from observations of the sun or stars. The methods are, first, the observation at the two stations of any independent celestial phenomenon, as: 1. Eclipses of Jupiter's satellites. 2. Eclipses of the moon. 3. Observations of meteors or shooting stars. To which celestial phenomena are added. 4. The observation of artificial signals, as the bursting of a rocket, a gunpowder flash, or the sudden exhibition or extinction of a bright light. These are phenomena in no way affected by the position of the observer; if visible at all they must be seen at the same absolute time at all places. If the observer at each of the two stations notes the time at which such phenomenon takes place, the difference of the observed local times gives at once the difference of longitude. In addition to these methods others are mentioned in which a certain phenomenon can be seen at two places, but not at the same absolute instant. Such are: 5. Eclipses of the sun. 6. Transits of planets over the sun's disk. 7. Occultations of stars by the moon. In the methods previously spoken of, the time at which the phenomenon occurred was independent of the position of the observer; the difference of times gave the difference of longitude. But in those now referred to such is not the case, the difference of time being compounded of the difference of longitude and the effect produced by parallax, the amount of which depends on the position of the observer. For, on account of the proximity of the various bodies of the solar system, the interposition of any one between the earth and another body or between the earth and a star exhibits for different positions on the earth's surface a different phase, and is seen at a different moment of absolute time. The effect of this parallax has therefore to be calculated. The lecturer proceeds to point out that all the methods for observing longitude yet spoken of have one disadvantage: opportunities for using them do not occur frequently enough. Methods generally available at any time are desired. Such a method is: 8. The general lunar method. The motions of the sun and planets are too small to be of practical use, or to speak more correctly, the motion of the moon is so much larger that it can be used with far greater advantage.

The apparent angular distance of the moon from the sun, or from one of the stars, for which distances (calculated for definite Greenwich times) are to be found in the *Nautical Almanac*, having been observed, all then required is that this observed distance shall be corrected for the effect of parallax, etc., by which a distance will be obtained such as would have been seen at the center of the earth. The observer, of course, knows his own local time of observation; by comparing his corrected distance with the distances given in the *Nautical Almanac*, the corresponding Greenwich time is inferred; the difference of the two times is the longitude from Greenwich. The great advantage of the method of lunar distances is that, excepting very near to new moon, it is always applicable, is perfectly general, and quite independent. For seamen, for use in exploring expeditions, or at any place at which it may be inconvenient to set up a regular observatory, it is especially useful. Possessed of a sextant, an artificial horizon, a pretty good watch, and a *Nautical Almanac*, the observer, when he comes to any convenient station, has only to wind up his watch, set it going, and commence work.

Mr. Ellis continues: In the lunar method, we find by lunar distances the then Greenwich time, and knowing the local time, so obtain the longitude. But suppose that instead of thus finding Greenwich time, instead of thus, as it were, reading Greenwich time from the face of the sky, suppose we carry Greenwich time with us. This brings us to: 9. The chronometer. You will see in what—by carrying a chronometer with us showing Greenwich time, or rather from which Greenwich time may always be obtained—the lunar method differs from the chronometer method. In both the local time is determined in the usual way, but while in the chronometer method we read off the corresponding Greenwich time from the face of the chronometer, in the lunar method we read it off in a more laborious way from the face of the sky.

Of other forms of the lunar method, there is one which may be just mentioned. It can only be used when instruments are set up as a regular observatory. It is: 10. Observation of the time of the moon's meridian transit, or of the differences of the times of transit of the moon and stars near the same parallel. The principle is, however, the same as in the general method, depending on the moon's motion between the times of passing two meridians. But all methods are now given up excepting in the determination of longitude at sea, when that which is the most accurate of all can be employed, I mean 11, the method by electric telegraph. To explain the telegraphic method, let us refer to our original supposition of two places having clocks, the constant difference between which is to be found.

Call the places A and B. At each station let the telegraph wire be brought near the clock and in the circuit of the wire let a galvanometer be placed. Then let a galvanic current be sent from station A to station B. Each galvanometer will indicate the passage of the current. Let the observers each note the time of its appearance. The difference of the times, corrected for errors of the clocks, gives the difference of longitude. A number of such signals being sent, a very accurate value of the difference is found. But when the two places are widely separated, a sensible time (some small fraction of a second) will elapse before the current sent from A can act through the intervening wire on the galvanometer, B. If, therefore, we were content with signals sent in one direction only, our longitude would be erroneous by the amount of time that the signals were retarded. If B be east of A, the signals sent from A would give the longitude too large. But by sending signals also from B, a value as much too small would be obtained. In practice, therefore, signals are always sent from both stations. Two values of longitude are thus obtained, one being as much too small as the other is too great. By taking then the mean of the two values, the retardation is eliminated, and a true result obtained.

* From a lecture by Mr. William Ellis, F.R.A.S., of the Royal Observatory, Greenwich.

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